Participants' Knowledge Harvesting during Product Development

Tolsby, June

Publication date:
2012

AALBORG UNIVERSITY

Participants' Knowledge Harvesting during Product Development

Doctoral Dissertation
by
June Tolsby
Submitted at Aalborg University, Faculty of Social Science, Department of Business Studies
under
The ETIC Programme (ETIC – The European Doctoral Programme on the Economics of Technology and Institutional Change)

Acknowledgements

Support from family made it possible to finish this doctoral thesis. My husband and daughters pushed me, comforted me, and helped me, respectively, to make me complete my thesis. Without their love, I would have been lost.

I am in dept to my beloved father Hans and my mother Alice, and my in-laws Ragnhild and Knut. The loss of my mother, father, and my mother-in-law was devastating for us all. We lost our dear aunt Marit in January 2011.

I thank Aalborg University Department of Business studies for letting me in on their doctoral programme, giving me financial aid and supervision. Financial support for this research project comes from the LOK (Management, Organisation, and Competence) Centre's research programme PIE (Product Innovation, Interactive Learning, and Economic Performance of Danish SME).

My main supervisor Professor Jørgen Gulddahl Rasmussen has always been ready to give feedback, to make sure that I was moving in the right direction. His continuous support and trust in my abilities made me finish this thesis.

Professor emeritus Reinhard Lund led me through the empirical data collection phase, with his patience and valuable advices.

I am grateful for help from Professor Bengt Åke Lundvall, my second supervisor, with an earlier version of the research question.

Much appreciation also to Birgitte Gregersen, Jesper Christensen, Anker Lund Vinding and Dr. Pun-Arj (former PhD student) of the IKE group for interest in my earlier works. My gratitude also goes to Dorte Bamlyer the IKE group secretary for her positive outlook on life, and for making my stay at the University a pleasant one.

Thanks to my dear friend, Professor Eevi Beck, at University of Oslo, Institute for Educational Research, who gave valuable help on an earlier version of my thesis.

Much appreciation goes to Dr. George Allan, at University of Portsmouth, School of Computing, for his valuable advices on grounded theory.

I appreciated that Leif Nyland provided me with leave of absence, and I valued my research collaboration with Per Kirkebak both former colleagues at Ostfold University College, Faculty of Engineering. Per sadly passed away in November 2010

Thanks also to the steering group of the Ostfold module of the Norwegian Research Council's National Research Programme VS2010 (Value Creation 2010 later called VRI2010) represented by Knut Aarvak at Ostfold Research Institute (Østfoldforskning) for some financial support.

Finally, I want to mention my colleague Professor Petter Øyan Dean at Oslo and Akershus University College, Faculty of Technology, Art and Design, my former colleague Sissel Larsen at Ostfold University College, Faculty of Engineering, and all to current and former colleagues that have paid an interest in my work.

I hereby submit my thesis, any faults or inconsistencies it may contain, are my sole responsibility.

June Tolsby
Halden/Aremark, Norway, 2012

Table of Contents

Opsummering

I denne afhandling er de ansattes forståelse af produktudvikling indarbejdet i en ny type produktudviklingsmodel. Dette er gjort for at forklare, hvordan de ansattes beskrivelse af produktudvikling påvirkning deres deltagelse i produktudviklingsprojekter. For at kunde forklare en sådan indflydelse har jeg analyseret hvordan de ansatte taler om produktudviklingsprojekter og tolket dette til plausible beskrivelser og forklaringer av udviklingsprocessen. En fleksibel produkt udviklingsmodel er udviklet, som kan hjælpe projekt deltagerne med at forstå og kontrollere fremdriften i projekter. At vide hvordan deltagere i udviklingsprojekter tolker sin deltagelse giver ny indsigt og en ny udviklingsmodel bedre egnet til at fange realiteterne i virksomhedens innovations proces.

De hidtil eksisterende produktudviklingsmodeller lægger for lidt vægt på, hvordan de ansattes forstår produktudvikling, hvordan de udforsker opgaver, og hvordan dette påvirker de formelt fastsatte aktiviteter i produktudvikling.

Ni kategorier er udviklet i denne afhandling for at forklare, hvordan de ansattes opfatning af produktudvikling kan defineres som en funktion af de formelt fastlagte aktiviteter. De ni kategorier er: produkttilblivelse (project emergence), kundskabindhøsting (knowledge harvesting), fleksibel og koordineret projektplanlægning (flexible and coordinated project planning), strategiske overvejelser (strategic considerations), projektlederens evne til at justere (project manager compliance), inkludering ved behov (inclusion on demand), markedsbindinger (market bindings), produktionsfleksibilitet (productional flexibility) og kulturelle kendetegn (cultural traits). Disse kategorier blev udviklet ved hjælp af en grounded theory inspireret tilgang.

Ved at sammenstille disse kategorier i en model er det mulig at vise hvorledes kategorierne fluktuerer i forhold til projektets tidslinje. Dette sker ved at kategorierne enten styrkes eller svækkes afhængig af hvordan beslutningerne under produktudviklingen justeres af de ansattes ud fra deres kundskaber om virkeligheden.

Den mest centrale kategori, som gennemsyrer denne afhandling, er, hvordan kundskaber indhøstes. Denne kundskapsindhøstning forklarer, hvordan læring sker under produktudviklingsprocessen. De ansattes kundskapsindhøstning kan relateres til følgende seks processer:

1. Kundskapsindsamling – Processer med aktiv involvering og eksponering for hændelser og mennesker. Kundskab opsamles fra eksterne kilder gennem deltagelse i eksterne projekter, og eksternt samarbejd. Projekt lederens motiver influerer på hvilken kundskab der samles ind. Motiverne kan være et ønske om å være leverandør for en kunde, å være i font af udviklingen, å tilegne sig kompetence, ud fra økonomiske hensyn, å identificere nye udviklingskriterier, og å være i stand til å beholde sine ansatte ved at stimulere deres teknologiske interesser.
2. Gøre kundskab synlig – Processer hvor man identificerer hvilken information der er behov for i de ulige projekter, og er i stand til at distribuere samt kontrollere kundskaben. Kundskaben vil bli distribueret og kontrolleret ud fra hvilke produkter der skal udvikles, og hvilken kundskab de ansatte har. Lige vigtig er der at ha kendskab til hvilken kundskab virksomheden ikke ønsker at ha.
3. Kundskabsintroduktion – Processer hvor projekt lederen sørger for at kundskaben tilbageføres til projekt gruppen.
4. Kundskabsunderskud – Situationer hvor mangel på kundskab opstår fordi personel slutter, eller hvor virksomheden ikke har nogen kundskab. For at kompensere for kundskabs mangler høster virksomheden fra personel som er ved at slutte, og ved at invitere eksperter ind i projekt gruppen.

5. Kundskabskultivering – Processer hvor de ansattes får modificeret sine opgaver, hvor de ansatte bliver tildelt nye opgaver, og hvor de ansatte får gå på kurs for å tilegne sig ny kundskab.
6. Paratkundskab – Kundskab der er baseret på lang tids praksis, er relateret til gamle produkter, der kun i ringe grad er dokumenteret – hvis de i det hele taget er dokumenteret - , og den bliver taget i brug, når den ansatte bliver konfronteret med et problem, der har ligheder med problemer fra den ansattes fortid. Influeret av tidligere tanker, følelser, og kundskab opnåede gennem sanserne mere end gennem abstrakt resonerende.

De ansattes kundskapsindhøstning sker generelt som et resultat af deres engagement i en given proces. Inden for produktudviklingsprocessen er engagement et resultat af en inkludering af de ansatte baseret på behovet for at anvende deres kundskaber og er samtidig koordineret af en projektleder, der har kendskab til disse kundskaber. Når de ansatte inkluderes som deltagere i projektgruppen, viser dette samtidig deres evne til at koordinere, deres evne til at tilegne sig kundskaber, deres holdninger og de følelsesmæssige reaktioner på de fænomenerne, de eksponeres for. Hvad den ansatte bringer ind i en sådan proces omfatter deres tidligere erfaringer fra tidligere handlinger (Mead, 1912).

På denne måde udvikler de ansatte sine kundskaber og høster kundskaber gennem diskussioner, hvor de reflekterer over sine erfaringer og får løst problemer. Et kundskabsgab, der opstår som følge af tab af ansatte, bliver fyldt op som et resultat af den organisatoriske evolution, ændringer i teknologi, ændringer i procedurer og arbejdsprocesser. Over tid handler knowledge management ikke om at tælle og notere, men om at indse at tab af kundskab ikke nødvendigvis behøver at kompenseres (Mårtensson, 2000).

Kundskapsindhøstning er nødvendig for at få fremmet produktudviklingsprojekter og hviler i sig selv på ansatte med kundskaber. Kundskapsindhøstning fører kun til et produkt, dersom de ansatte er i stand til at absorbere ny kundskab. Kundskab som igen er baseret på, at de tidligere har opbygget kundskab, herunder i særlig grad paratkundskab.

Kundskabsindhøstning sker ved at praktisere en fleksibel og koordineret projektplanlægning, hvor både strategiske overvejelser og overvejelser om fleksibilitet i produktionen bliver taget ind. Kundskabsindhøstning som bliver udført ved brug af en produktudviklingsmetode kobler produktudviklingsprocessen til markedet. Dette sker gennem at gøre ingeniørerne og projektlederne mere markedsorienteret, ved at ændre deres ansvar, ved en stærkere fokus på indtjening og ved et tættere samarbejde med brugerne. Kundskabsindhøstning kræver inkludering ved behov og en kompetent projektleder, som er i stand til at opfylde en række faglige krav, men det at være en god projektleder kommer i høj grad inde fra den enkelte. Kundskabsindhøstning bliver stimuleret, når organisationen indeholder visse kulturelle kendetegn såsom gode sociale faciliteter for de ansatte og en god faglig organisering.

En udviklingsfilosofi kan opbygges på baggrund af de ni kategorier. Kernen i denne udviklingsfilosofi er at sikre en dynamisk planlægning af output, hvor ideer kontinuert bliver evalueret og mål op mod produktionskapacitet, procestid, markedsstrategier og produktportofolio. Og hvor de ansattes kundskaber bliver stimuleret og deres adfærd bliver søgt reguleret. I praksis sker dette gennem regelmæssige møder, ved at forsøge at forstå andre ansatte og kunderne, ved at opmuntre de ansattes motivation for at arbejde med et projekt og ved at tilladte dem at udvikle kundskaber. Manglede evne til at kommunikere præcist med de ansatte vil medføre ødelæggelse af produktudviklingsprocessen.

De eksisterende produktudviklingsmetoder fokuserer ikke på og støtter derfor ikke disse centrale kategorier i produktudviklingsprocessen. Udvikling af nye produktudviklingsmetoder må derfor i fremtiden være fleksible nok til at medtage de ansatte forståelser . Hvis dette ikke sker, vil produktudviklingsmodellerne mislykkes med at fungere som en effektiv guide i udviklingsprocessen.

Søgeord: product development, learning, knowledge harvesting, trust, grounded theory (GT), pragmatism, symbolic interactionism, national system of innovation.

Summary

The new product development model, developed in this thesis, explains how employees' reflections over product development influence their participation in development projects. In order to explain such an influence I analyse how employees talk about product development projects and interpret this into plausible descriptions and explanations of the development process. A flexible product development model is developed, which can help the project participants to understand and control project progression. Knowing how participants in development projects interpret their participation produce new insights, and a new development model, better fit to capture the reality of the company's innovation process.

Current development models pay little attention to how employees comprehend product development, how they explore tasks, and the effect on formally defined tasks in product development.

Nine categories explain how employees' grasp product development as a function of formality. The nine categories are: project emergence, knowledge harvesting, flexible and coordinated project planning, strategic considerations, project manager compliance, inclusion on demand, market bindings, productional flexibility and cultural traits. The categories emerged by apply a grounded theory inspired approach on the empirical data. .

Combining the categories into a model demonstrate how they fluctuate in accordance with the project timeline going either towards strong or weak depending on how the decisions influence employees' knowledge of reality.

The central category to permeate is knowledge harvesting. Knowledge harvesting explains how learning take place during the product development process. Employees' knowledge harvesting are related to six main processes:

1. Knowledge Collection - Processes of active involvement and exposure to events or people. Knowledge is collected from external sources through participation in external projects, and external collaborations. What knowledge is collected will be influenced by the project manager's project motives. These motives are to be a supplier for a customer, to be in front of development, to gain competence, to take economical considerations, to identify new development criteria, and to be able to keep employees by nourishing their technological interest.
2. Make Knowledge Visible – Processes of identification of what information the different projects needs, and ability to distribute and control knowledge. Knowledge will be distributed and controlled depending on what products to develop, and what knowledge employees' have. Furthermore, equally important is it to know what knowledge the company does not want to possess.
3. Knowledge Introduction – Processes where the project manager feeds knowledge into the project group.
4. Knowledge Deficiencies – Conditions where knowledge lacks occur because personnel leave, or where the company have no prior knowledge. To compensate for knowledge lacks the company harvest from personnel leaving the company, and by letting experts into the project group.
5. Knowledge Cultivation – Processes where changing employees' tasks, assigning employees to new tasks, and ensuring they attend courses to gain new knowledge.
6. Para-knowledge – Historical knowledge that is poorly documented, if documented at all, gained through long experience, and recallable once facing problems similar to problems in the employees' past experiences. Past thoughts, feelings, and knowledge acquired through the sense rather than through abstract reasoning.

Employees' knowledge harvesting is a result of their engagement in a process. Within product development, engagement results from inclusion of employees'. The project manager with knowledge about

employees' knowledge will engage the appropriate employee knowledge in the development project. Once included in the project group employees' demonstrate their coordination skills, their ability to acquire knowledge, their attitudes, and emotional reactions to the phenomenon. What employees' bring to a process includes their previous experiences from earlier actions (Mead, 1912).

Furthermore, employees develop their knowledge and harvest knowledge through reflecting over their experiences, and solving problems. Filling knowledge gaps, resulting from loss of employees happens through organizational evolution, changes in technology, changes in procedures, and work processes. Over time, knowledge management is not about counting and recording, but to realise that loss of knowledge not necessarily needs compensation (Mårtensson, 2000).

Knowledge harvesting is necessary for product development projects to emerge and it relies on knowledgeable employees. Knowledge harvesting will only lead to a product, if employees are able to absorb new knowledge based on having prior knowledge and para-knowledge. Para-knowledge has four characteristics; stem from long practice, related to old products, poorly documented, if documented at all and recallable once faced with a problem similar to a problem in employees' past.

Knowledge harvesting happens by practicing a flexible and coordinate project planning where both strategic considerations and productional flexibility are considered. Knowledge harvesting done using a product development method will bind the product development process to the market by making engineers and project managers more market oriented by changing responsibilities, a stronger emphasis on earnings and a closer collaboration with users. Knowledge harvesting requires inclusion on demand and a capable project manager able to comply with certain requirements, but being a good project manager comes from within the person. Knowledge harvesting will be stimulated when the organization inhabits certain cultural traits such as social facilities for employees and a good workers union.

A development philosophy emerges because of dealing with the nine categories. The core in the development philosophy is to ensure a dynamic planning of output continuously evaluating ideas and measuring the production capacity, processing time, marketing strategies, and products' portfolio. Moreover, employees' knowledge is stimulated and their behaviour regulated. In practice, this happens through regular meetings, by making an effort to understand employees and customers, by encouraging employees' motivation for a project and allow employees to develop knowledge. Failure to communicate correctly with employees will cause violation of the product development process.

Current product development methods do not envisage, or support, these central categories in the product development process. Development of future product development methods need to be flexible enough to consider employees comprehensions, otherwise the product development models fail to function as guidance of the development process.

Keywords: product development, learning, trust, knowledge harvesting, grounded theory (GT), pragmatism, symbolic interactionism, national system of innovation.

I dedicate this thesis to my father, who taught me never to give up, and to my husband and daughters, who stood by me through our difficult times.

1. Introduction

My thesis examines how employees' reflections over product development influence their participation in development projects. In order to explain such an influence I analyse how employees talk about product development projects and interpret this into plausible descriptions and explanations of the development process. The aim is to develop a flexible product development model, which can help the project participants to understand and control project progression.

I study how employees' interpret the project development processes, in search of a better understanding, and better tool, to handle innovation projects. Knowing how participants in development projects interpret their participation can produce new insights, and a new development model, better fit to capture the reality of the company's innovation process.

Product development models shall ensure project progression, and project results (Andreasen and Hein, 1987; Pugh, 1991; McGrath, 1996; Hart & Baker, 1994; Cooper, 2001). The models are tools that shall enable companies to produce products efficiently, and help them to survive in a competitive environment. However, there is reason to believe that individuals solve product development problems by adapting procedures and development models to their own experiences and practices. This happens as employees' apply their knowledge, and learn new things during the evolvement of development projects. These changes result from organizational learning, and product development models need to capture these changes. Moreover, to incorporate employees' adaptations into a model we need to understand how this organizational learning occurs. Therefore, solving product development problems requires a better understanding of how the participants interpret development models and routines, and their implementation.

To understand how individuals' interpretations of the development process affect how they comprehend and conduct their development process my thesis study a company in the welding industry producing welding equipment.

Some of the challenges facing the welding industry are cost, productivity, technology, welding processes, quality standards, materials performance, market considerations, environmental issues, health issues, safety issues, and education and training. To handle such challenges the company uses the well proven, Stage-Gate and Integrated Product Development models, to structure their development process.

In this thesis, I investigate employees' perspectives on product development, and incorporate the results into a product development model by applying the following main research question:

How do employees' comprehensions of product development projects change their development model and how can this knowledge be used to create a new model better fit to their reality?

1.1 Method Applied to Investigate the Research Question

My investigation of the research question uses a Grounded Theory Inspired Approach (GTIA).

The main characteristic of Grounded Theory (GT) is to generate theory. However, the application of GT requires the researcher to follow a set of procedures when collecting and analysing data.

Properly performed a GT approach involves going back and forth between data analysis and data collection. New theoretical conceptualizations develop between each new data collection phase as the researcher processes the empirical data. The interviewees will confirm, disconfirm, or modify the concepts when presented to them. Such a process grounds the concepts in the data. In reality, applying GT produces theory from using the interviewees' words and phrases (in vivo) or rephrasing the interviewees words or phrases though conceptualizing without loosing the intended meaning (in vitro).

GT operates almost in a reverse fashion to more traditional research. Rather than beginning the research with developing hypothesis, the first step in GT is data collection where varieties of models are applicable. Interviews, observations, or a combination of the two is common data collection models.

When conducting GT the data analysis goes through a set of consecutive steps.

The first step is to analyse the interview data in order to produce key points. The key points emerge from the collected data by using a series of codes, extracted from the interview text. Key points are used as an aid for the research to avoid a mass accumulation of data, which happens when the data is analyzed word-by-word and line-by-line. Key point coding ensures a encapsulation of the opinions appearing in the interview text in relation to their relevance for the research questions to be answered (Allan, 2003).

The second step is to use the key points and dense them into codes. The codes then become a denser description of what goes one in the studied field.

The third step is to use the codes and group them into concepts. Grouping codes into concepts make them workable, and an even denser description of the studied field emerges.

The fourth and final step is to develop the categories. The categories represent the basis for creating a theory, or a reversed engineered hypothesis. This engineered hypothesis comes out of the data, rather than from existing research theories. Hence, one refers to GT as a bottom-up approach. A GT approach starts in the field and not with theories.

The result of processing the empirical data through these four steps is that

> "Events, happenings, objects and actions/interactions that are found to be conceptually similar in nature or related in meaning are grouped under more abstract concepts termed categories" (Strauss and Corbin, 1999: 102).

GT does not require the researcher to have a fixed research question ready when going into the field. The researcher wants to investigate an area more broadly, and to analyse the data to identify the issues at stake in the studied field. Hence, applying GT means to use an explorative approach to how to study a research field.

GT aims to conceptualize the real world rather than testing existing theories or concepts on the world. Studies of reality are essential to formulate the research question. Using GT is a question of what the researcher wants to accomplish with her research. A researcher choosing to use GT wants to develop theoretical concepts using a process involving simultaneous data collection and data analysis.

Theories on GT provide detailed descriptions of how to process the empirical data (Martin and Turner, 1986; Strauss and Corbin, 1997; Glaser, 1994; Strauss and Corbin, 1998; Glaser and Strauss, 1999; Strauss, 2003).

Using GT starts by identifying the main ideas in the studied problem by analysing the data. This thesis uses interviews to collect data. By analysing, the interviewees' sentence-by-sentence key ideas emerge from the interviewees. Table 1 presents the first step in the data analysis.

Table 1: The conversion of Interview text to Key Points

Id	**Interview text**	**Key Points**
B1pr2	We are not a large company and have reasonably control on everything. Work delegated and someone given responsibility for de different parts.	Not a large company reasonable control on everything Delegate responsibility for project parts

Table 1 shows how to transform the data into a higher level of abstraction from the interview text to the key points.

Table 2 shows the next level repeating the process to reach an even higher level of abstraction going from key points to codes.

Table 2: The conversion from Key Points to Codes

Id	**Key Points**	**Codes**
B1pr2	Not a large company reasonable control on everything. Delegate responsibility for project parts	Company size and delegation of project responsibility gives control.

In table 3, the aggregation process moves to the next level of abstraction by aggregating codes to concepts.

Table 3: The conversion from Codes to Concepts

Id	**Codes**	**Concepts**
B1pr2	Company size and delegation of project responsibility gives control.	Development control

Table 4 aggregates the data from concepts to categories. The categories represent the final level of abstraction going from concepts to categories.

Table 4: The conversion from Concepts to Categories

Id	**Concepts**	**Categories**
B1pr2	Development control	Flexible and coordinated project planning

By processing the data through these consecutive steps, the data reaches a higher level of abstraction at each pass. At the final level, the abstractions represent the categories that become a theory. Chapter 5 presents a more detailed discussion of GT.

1.2 Thesis Outline

The structure in the remainder of this thesis is as follows: Chapter 2 presents an overview of welding and some of the challenges within the welding industry. Chapter 3 presents central theories within organizational learning, and knowledge management studies. Chapter 4 presents the scientific method used to investigate the empirical data. Chapter 5 presents the background of Grounded Theory (GT), and the characteristics of the Grounded Theory Inspired Approach (GTIA) developed for the research in my thesis. Then follows chapter 6 by showing the empirical data analysing, in detail, of one interview using GTIA (Appendix IX describes the complete data analysis). Chapter 7 presents the main categories found by investigating the empirical data. Chapter 8 presents how informants' conceptions relate to project timeline, and influence project progression. Finally, chapter 9 presents the conclusions and some points for future research.

2. Background for Influences on Welding

Welding is the process of joining two or more pieces of metal. There are many ways to make a weld and many different kinds of welds. Some processes cause sparks, and others do not even require extra heat (Cary, 1998). Furthermore, welding ranks, high among industrial processes and involves more sciences and variables than those involved in any other industrial process (Ibid.).

Photo 1: Illustration from Cary (1998).

Welding uses many different energy sources, including gas flame, electric arc, laser, electron beam, friction, and ultrasound. While often an industrial process, welding occur in many different environments, including open air, underwater and in space. Regardless of location, however, welding remains dangerous, and requires precautions to avoid burns, electric shock, poisonous fumes, and overexposure to ultraviolet light.

The company under investigation operates in the welding industry by producing welding equipment. The industrial conditions for the welding industry affect the market the company operates in and their product development process. Moreover, to understand the conditions for welding equipment production requires an outline of the influences on welding.

2.1 History of Welding

The history of joining metals goes back several millennia, with the earliest examples of welding from the Bronze Age and the Iron Age in Europe and the Middle East. The welding process joins materials, usually metals, or thermoplastics by causing coalescence (Cary and Helzer, 2005). By melting the work pieces and adding filler material to form a pool of molten material (the *weld puddle*) the welding process joins materials. The material becomes a strong joint when cooling down.

Welding transformed during the 19th century as Sir Humphrey Davy discovered the electric arc, and further advancement in arc welding continued because of the invention of metal electrodes by Nicolai Slavyanov (Ibid.). Further advancements in welding resulted form development of a coated metal electrode giving a more sable arc (Ibid.).

During the 1920s, major advances happened in welding technology, including the introduction of automatic welding, in which electrode wire was fed continuously. Shielding gas became a subject receiving much attention, as scientists attempted to protect welds from the effects of oxygen and nitrogen in the atmosphere. Porosity and

Photo 2: illustration from Cary (1998).

brittleness were the primary problems and the solutions that developed included the use of hydrogen, argon, and helium as welding atmospheres (Cary, 1998; Cary and Helzer, 2005).

The 1930s' saw the release of stud welding, which soon became popular in shipbuilding and construction (Cary, 1998). During the following decade, further advances allowed for the welding of reactive metals like aluminium and magnesium (Ibid.) In addition developments in automatic welding, alternating current, and fluxes resulted in major expansion of arc welding during the 1930s and then during World War II (Cary and Helzer, 2005).

Gas tungsten arc welding, which was perfected in 1941 after decades of development, was followed by gas metal arc welding in 1948, and this development allowed fast welding of non-ferrous materials but requiring expensive shielding gases (Cary, 1998). Shielded metal arc welding was developed during the 1950s, using a consumable electrode and a carbon dioxide atmosphere as a shielding gas and it quickly became the most popular metal arc welding process (Ibid.). In 1957, the flux-cored arc welding process debuted, using the self-shielded wire electrode with automatic equipment, resulting in greatly increased welding speeds, and that same year plasma arc welding was invented. Electroslag welding was introduced in 1958 and was followed by its cousin, electrogas welding, in 1961 (Ibid.).

Other recent developments in welding include the 1958 breakthrough of electron beam welding, making deep and narrow welding possible through the concentrated heat source. Following the invention of the laser in 1960, laser beam welding debuted several decades later and has proved to be especially useful in high-speed, automated welding. Both of these processes, however, continue to be quite expensive due the high cost of the necessary equipment and therefore they are not much applied (Cary and Helzer, 2005).

Today welding concentrate on minimizing labour costs in high production manufacturing, and hence industrial welding gets increasingly more automated (Cary and Helzer, 2005). Consequently, using robots in resistant spot welding within the automotive industry, and arc welding, increases (Ibid.). Robot welding means a mechanized device both hold the material and perform the welding operation.

2.2 Use of Welding

Nearly everything we use in our daily life involves welding or is made by welding

equipment (Cary, 1998). Welders help build metal products from coffeepots to skyscrapers. They help build space vehicles and millions of other products ranging from oil drilling rigs to automobiles. In construction, welders are virtually rebuilding the world, extending subways, building bridges and helping to improve the environment by building pollution control devices (Cary, 1998).

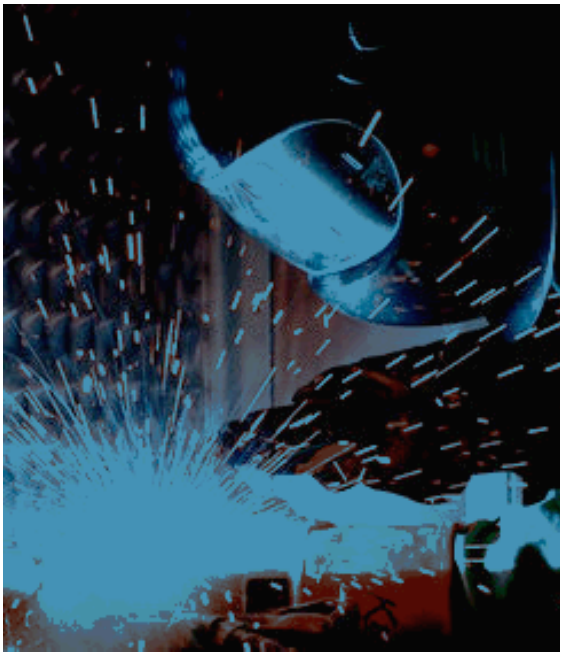


Photo 3: Arc Welding from (Wikipedia, 2010)

Many industrial groups such as machinery manufacturers producing agricultural, construction, and mining machinery employ welders (Cary, 1998). Bulldozers, cranes, material handling equipment, food-processing machinery, papermaking and printing equipment, textiles and office machinery, also involves welders (Cary, 1998).

Additionally, welders produce heat exchangers, tanks, sheet metal, prefabricated metal buildings, and architectural, and ornamental work (Cary, 1998).

Transportation represents another area with heavy use of welding. Two major groups use welding within transportation: manufacturers of transportation equipment except motor vehicles, and motor vehicles and equipment (Cary, 1998). The first group includes shipbuilding, aircraft, spacecraft, and railroads. The second group includes automobiles, trucks, buses, trailers, and associated equipment (Ibid.).

A small group of welders belongs to the group of repair services (Cary, 1998). Repair services include maintenance and repair on automobiles, or refer to the welding performed on industrial and electrical machinery to repair worn parts (Ibid.). In addition, the mining, oil extraction, and gas extraction industries represent another group in the same category (Ibid.). Within these industries, welding work involves drilling and extracting oil and gas or mining of ores, stone, sand, and gravel. The primary metals industries such as steel mills, iron, and steel foundries, smelting, and refining plants, also employ welders (Ibid.). The work done is maintenance and repair of facilities and equipment. Another group is the electrical and electronic equipment companies. Welding done by electrical and electronic equipment companies runs from work on electric generators, battery chargers, to household appliances (Ibid.)

2.3 Costs and Trends affecting Welding

The welding industry consists of the users of welding techniques as well as the companies, universities and other organisations that provide the equipment, materials, processes, and support services for welding (America, 1998: 1).

Welding is a precise, reliable, cost-effective, and high-tech model for joining materials. Welding is applied to a variety of materials, products, and uses, and it includes as advanced technology as lasers and plasma arcs (America, 1998: 1).

The cost of welding as an industrial process plays a crucial role in manufacturing decisions (Cary, 1998). Many different variables affect the total cost, including equipment cost, labour cost, material cost, and energy cost (Ibid.). Equipment cost varies depending on the process, from inexpensive for models like shielded metal arc welding and oxyfuel welding, to extremely expensive for models like laser beam welding and electron beam welding (Ibid.). Because of a high cost, only high production operations use laser beam welding. Similarly, because automation and robots increase equipment costs, they are only implemented when high production is necessary (Ibid.).

Labour cost depends on the deposition rate (the rate of welding), the hourly wage, and the total operation time, including both time welding and handling the part. The cost of materials includes the cost of the base and filler material and the cost of shielding gases. Finally, energy cost depends on arc time and welding power demand. For manual welding models, labour costs generally make up the vast majority of the total cost. As a result, many cost-savings measures focus on minimizing the operation time. To minimize operation time, welding procedures with high deposition rates can be selected, and weld parameters can be fine-tuned to increase welding speed (Weman, 2003).

Mechanization and automation are often implemented to reduce labour costs, but reduction of labour costs frequently increases the cost of equipment and creates additional setup time. Material costs tend to increase when special properties are necessary, and energy costs normally do not amount to more than several percent of the total welding cost (Weman, 2003).

In recent years, in order to minimize labour costs in high production manufacturing, industrial welding has become increasingly more automated, most notably with the use of robots in resistance spot welding (especially in the automotive industry) and in arc welding (Lincoln Electric, 1994). In robot-welding mechanized devices both hold the material and perform the weld, and at first spot welding was its most common application. As the technology advances, robotic-arc welding becomes increasingly popular (bid.).

However, welding as an industry is moving to countries with a low-cost workforce, and with less educated welders. This development put pressure on how welding machines should be operated and developed. The welding machine needs to be

easy to operate independent of the welding process they are aimed for.

In 1998 more than 25 senior managers and experts from the United States, welding community met at the National Institute of Standards and Technology in Gaithersburg, Maryland (America, 1998). The purpose of the meeting was to start a dialogue about the future of the welding industry. The workshop produced a document called, Vision for Welding Industry, describing the challenges and opportunities the industry will face in 2020:

- Welding needs better integration with the production cycle
- Training of welders and welding technologists need to be more comprehensive and scientific
- Make the welder's working environment more attractive
- Make the image of welding as the weakest link in fabrication obsolete
- New materials development will increasingly incorporate weldability (America, 1998: 2).

From a normative perspective, a set of strategic targets will solve the challenges defined by the U.S. welding industry. According to America (1998: 21-25), the industry needs to deal with the following seven strategic targets:

Cost and productivity – aim towards cost-effective welding operations by conducting up-front design and development to get a larger market share. Cost-effective welding operations can be done by reducing time and costs of welding. Increase productivity and improve welding processes and products by focusing on welding quality, reduce welding time, use automation to reduce labour costs, and use simulation to model welding.

Technologies and processes – enhance welding in the manufacturing process by using new technology and new processes. Improve welding design using simulation and information technology. Integrate welding in the entire factory using technologies for upstream and downstream integration. Use open architecture and automaton in welding technology based on plug and play compatible equipment. Seek new ideas from other industries that are applicable to welding such as sensor and computer industries.

Quality standards – A focus on quality standards should help to improve quality on welds and fabrications by focusing on corrosion resistance, strength, fatigue-resistance, and eliminate need for inspections. It involves predicting the structure, and life–time of fabricated products, revelation of conditions that lead to defects and cracking, to make welding machine codes and standards more flexible, in order for machines to be sold in international markets.

Materials Performance – Welding producers need to use advanced, cost effective, and high-performance materials suitable for its application. The aim is to promote welding as the first choice when joining materials.

Markets and Applications – These requirements focus on getting more market shares by increasing the global markets for welding.

Education and Training – These requirements aim to attract more people to welding both at the workplace and in the academia. It requires more people trained in fields related to welding such as material scientists, mechanical and systems engineers, architects and product designers.

Energy, Environment, Health and Safety – These requirements aim to reduce energy cost in pre- and post-heat operations by using advanced materials and processes. Producers of welding equipment need to take environmental concerns such as green-technology and life-cycle perspective on welded products. Ensure welders health by addressing hazards such as burns, welding fumes, noise, electric shocks, and falls.

From a socio-economic perspective, these welding challenges demonstrate that the driving innovation forces within welding are by far technology-demand-pull factors (Geels, 2002).

3. Theoretical Discussion

Employees participating in development projects are part of an organizational learning process. In relation to the research question, the knowledge management principles, the activities performed, the technology and resources available, and the people involved in the organizational learning process, influence employees' comprehensions.

Theoretically, the research question belongs to the field of knowledge management, and of organizational learning. In this chapter my research question is discussed in relation to the following themes: what is knowledge management, how is knowledge management related to learning, how does knowledge management relate to organizational learning, and what are the dominating tensions within organizational learning. Furthermore, how does knowledge management relate to technological innovations, how is knowledge management seen from a macroeconomic perspective, how does knowledge management relate to product development, and how does knowledge management relate to user-producer relationships. Next, I discuss how trust is central for organizational learning. This chapter ends with an overview of the discussed knowledge management issues.

3.1 Introducing Knowledge Management

Knowledge management in organizations deals with how knowledge as a resource can be controlled and managed (Hislop, 2009). However, the literature within knowledge management is split into two main streams of interpretations. One stream regards knowledge as "an entity/commodity that people possess, but which can exist independently of people in a codifiable form", and the other stream regards knowledge "not as a codifiable object/entity, but instead emphasizes the extent to which it is embedded within and inseparable from work activities or practices" (Hislop, 2009: 19, 33). I do not see these streams as contesting approaches, but as complementary. Nevertheless, the investigation conducted in this thesis has lead me to the conclusion that if knowledge is treated purely as a commodity, it will not take into consideration the important social dimension of peoples learning process.

A key assumption lying behind knowledge management is the importance for organizations to manage their workforce's knowledge. Furthermore, such an assumption is based on three considerations: 1) to view knowledge as a key asset necessary to manage, 2) to take into consideration the increase in intellectual work in organizations, and 3) to look at the effective management of knowledge as a necessity for the

organizations' competitive advantage (Hislop, 2009). These assumptions influence the research development within the knowledge management field.

As already mentioned, the knowledge management field is split into two theoretical traditions.

The first tradition stems from *a positivistic epistemology* where the fundamental idea is that the social world can be studied scientifically, i.e. that social phenomena can be quantified, measured, and established as general laws and principles, giving objective knowledge (Hislop, 2009). When knowledge management research is based on a positivistic philosophy, knowledge sharing is viewed as sender – receiver process. "The sender, in isolation from the receiver, can produce some whole explicit knowledge, and then transfer it to the receiver" (Hislop, 2009: 26). The receiver in such a process is able to understand and use the knowledge without the need for any interaction with the sender (Ibid.). Furthermore, no information is lost during the transfer of knowledge (Ibid.).

The second tradition within the knowledge management field has a practice-based perspective on knowledge. A practice-based perspective on knowledge looks at knowledge as embedded within and inseparable from, work activities and practices (Ibid.). "Practice therefore connects knowing with doing" (Gherardi, 2000: 218). This perspective on knowledge is termed *the epistemology of duality* (Schultze & Stabell, 2004). The duality lies in the interaction between peoples' knowledge and their activities. A practice-based perspective on knowledge can be found within a number of philosophical traditions, as illustrated in table 5.

Table 5: The theoretical perspectives related to a practice based perspective on knowledge adapted from (Hislop, 2009: 34)

Writer	**Theoretical perspective**
Empson (2001)	Interpretive
Blacker (1995)	Activity theory
Tsoukas (1996)	Ethnomethodology/interpretive philosophy
Cook & Brown (1999)	American pragmatists
Lave & Wenger (1991)	Situated learning theory
Schuman (2003)	Actor network theory

All of the theoretical perspectives in table 5, emphasis different aspects of how knowledge relates to people and practice. However, what these different theoretical perspectives have in common are:

1. "Knowledge is embedded in practice
2. Tacit and explicit knowledge are inseparable
3. Knowledge is embodied in people
4. Knowledge is socially constructed

5. Knowledge is culturally embedded
6. Knowledge is contestable" (Hislop, 2009: 34).

The first perspective, characterising knowledge as embedded in practice, emphasis that knowing is inseparable from human activity (Orlikowski, 2002). All knowledge involves an element of activity by either sharing, using, developing or creating it (Hislop, 2009). Hislop's perspective on learning, view knowledge and development of knowledge as occurring ongoing, based on the routine activities that people undertake.

The second perspective defines tacit and explicit knowledge as inseparable (Ibid.). This is based on the idea that no knowledge is fully explicit since all knowledge has a tacit dimension (Hislop, 2009). According to Johnson, Lorenz and Lundvall (2002) tacit and codified knowledge must be seen as complementary.

> "It does not seem to be a good idea to regard them as being in contradiction to each other or as simply substituting for each other. It is more useful to refer to a tacit dimension of knowledge rather than to a knowledge stock divided into a tacit part and a codified part, and then decide if the border between the two parts should be moved" (Johnson et. al 2002: 256).

Furthermore, Johnson et. al (2002) claim that parts of the local tacit knowledge never get codified, but are rather inactivated, and forgotten and lost after a time. The degree to which knowledge can be codified, and how complex the knowledge is, shape how easy it transfers between organisations (Kogut and Zander, 1992). According to Nonaka and Konno (1998), explicit knowledge is expressed through data, formulae, specifications, manuals, etc. and can be transmitted between individuals formally and systematically. Tacit knowledge on the other hand is highly personal and difficult to formalise and communicate to other people (Ibid.). For Nonaka and Konno (1998) knowledge creation is a constant interchange between the two. Nonaka and Konno claim that organisational learning is a process where tacit knowledge becomes explicit, when shared with others in a socializations phase where individuals spend time together in joint activities. However, the language used in a practice is permeated by the practice it has developed in. Therefore, codification of knowledge is more than just a conversion from tacit to explicit knowledge (Kogut and Zander, 1992).

> " Simply transferring knowledge is insufficient for innovation to occur in a partnering relationship – organisations need to be able to recognise the value of knowledge and apply it strategically" (Kogut and Zander, 1992: 979).

To make sensible use of knowledge requires the knowledge to be structured according to a set of easily communicated identifiable rules (Kogut and Zander, 1992).

The third perspective on knowledge sees knowledge as embodied. It is impossible to make all knowledge fully explicit, because knowledge is personal, and based on personal judgement (Hislop, 2009).

The fourth and fifth perspective on knowledge sees knowledge as socially and culturally constructed (Hislop, 2009). A perspective on knowledge as socially constructed and culturally embedded, emphasis that knowledge is never neutral and unbiased, and to some extent inseparable from the values of those who produce it (Ibid.).

The sixth perspective on knowledge sees knowledge as contestable. This perspective emphasis that what constitutes knowledge is open to dispute due to the social, subjective, and cultural embeddedness of knowledge (Hislop, 2009). According to Hislop, a contestable view on knowledge opens up for conflicts, politics, and power. He claims this happens because there are different opinions, and understandings of how to explain and understand a piece of knowledge. The result is contestable conceptions of what constitutes legitimate knowledge.

The implications for organizational knowledge, resulting from the different perspectives on the conditions for knowledge production, are that they will produce different managerial challenges, and problems (Ibid.). According to Becker (2001), this disperse nature of organizational knowledge will cause in particular three problems.

1. The first problem is that of large numbers. With a large number of employees in the organization, the knowledge becomes fragmented and dispersed and makes it difficulty to create an overview of knowledge (Ibid.). Furthermore, large numbers challenge the amount of resources needed to bring together a fragmented and dispersed knowledge base (Ibid.).
2. The second problem is the asymmetry relating to the unevenly dispersed knowledge and learning across the organization (Ibid.). Moreover, individuals' knowledge relates to the nature of the tasks, the social contexts they work in, and it is necessary to collaborate with people with different knowledge resources (Hislop, 2009). Furthermore, not only are peoples' knowledge different, but also based on different assumptions, values, and interpretations (Ibid.). This makes it difficult for people in different departments and functions to communicate and collaborate (Ibid.).
3. The third problem regarding dispersed knowledge is related to the uncertainty it creates, and the challenges it poses to managerial decision-making, since individual organizational actors find it impossible "to make decisions with full and relevant knowledge" (Hislop, 2009: 44). Hence, the central idea within a practice-based perspective on knowledge is that organizational knowledge will always be fragmented and incomplete, and

therefore any attempts to collect knowledge in a central location are likely to be limited (Hislop, 2009).

In her literary review on the origins of knowledge management and how to understand knowledge management, Mårtensson (2000) claims knowledge management to be "a prerequisite for higher productivity and flexibility in both the private and the public sectors" (Mårtensson, 2000; 204). Figure 1 below shows how Mårtensson categorizes knowledge management as part of the strategy to handle a company's intellectual capital.

Figure 1: A perspective on knowledge management adapted from Mårtensson (2000: 206)

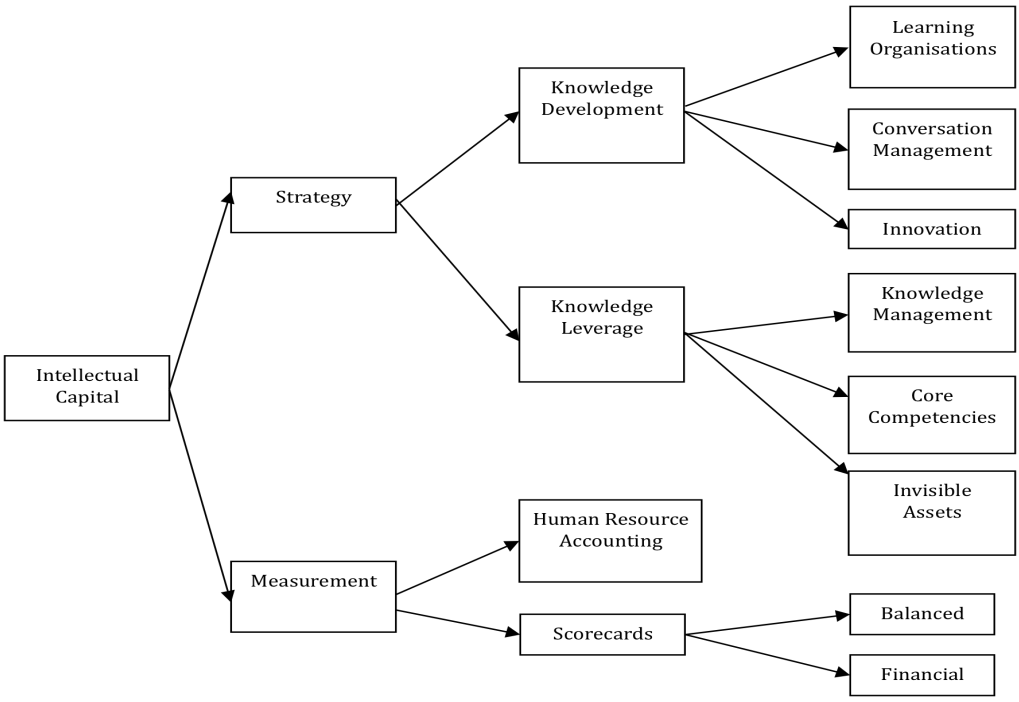


Figure 1 illustrates how knowledge management administration and facilitation handles the intellectual capital of a company. Moreover, knowledge management equals strategy and measurement (Mårtensson, 2000). According to Mårtensson, managing knowledge is a question of measuring instead of a question of understanding and learning.

3.2 Knowledge Management of Learning

To understand how knowledge management relates to learning, it is necessary to define learning. In English, the verb, to learn, means "to get knowledge or skill in a new subject or activity" (Cambridge, 2007a). Such an explanation introduces the noun

knowledge, and what is knowledge? The noun knowledge means "understanding of or information about a subject which a person gets by experience or study and which is either in a person's mind or known by people generally" (Cambridge, 2007b). Learning results in a change in our conception of a subject, and changes our consciousness in relation to the subject.

According to Mead (1967), consciousness emerges "from the standpoint of its objects and the relation of these objects to conduct" (Mead, 1967: 401). He claimed that our consciousness about objects in the world establishes because of stimulation of our senses and combining these sensuous impressions with cognitive images stemming from previous experiences. For Mead (1967) previous experiences result from an action initiated by the same stimulus.

Figure 2: Building a consciousness adapted after Mead (1912)

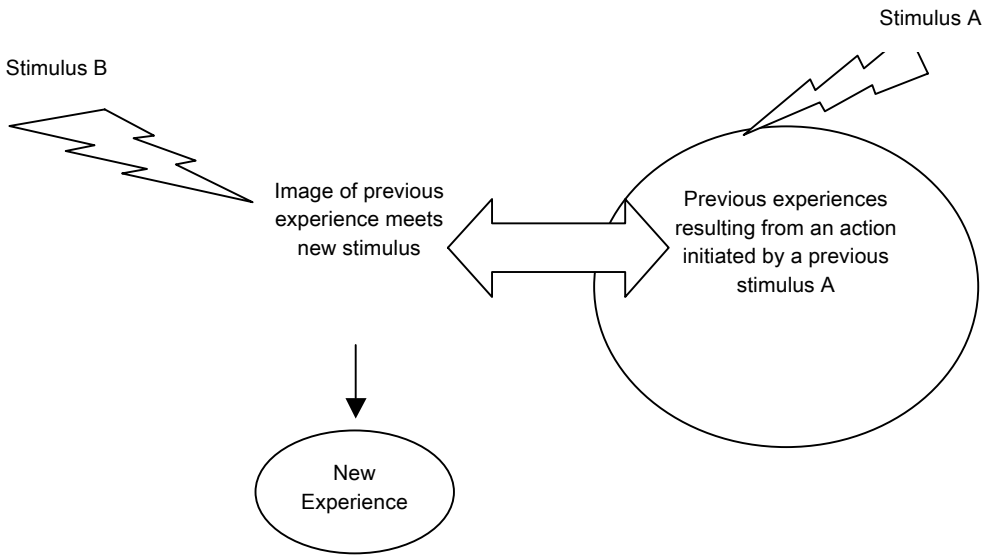


Figure 2 demonstrates the establishment of our consciousness. First, we receive through our senses some stimulus B, which triggers some image of a previous experience based upon another stimulus A. Next, new stimulus associate with our previous experiences, or an image of an action related to the previous experience, and expand our knowledge base. Mead (1967) claims our consciousness results from association with previous experiences, and not from particular rules or procedures resulting from adaptation using punishment and reward.

Wenger (1998) explains how practice extends beyond the learning process into a community of practice, where our identity results from continuous processes of negotiation and renegotiation of meaning. Members of a community of practice participate in a shared activity or enterprise (Ibid.). The participation embraces "all kinds of relations, conflictual as well as harmonious, intimate as well as political, competitive

as well as cooperative", and "our ability (or inability) to shape the practice and that participation goes beyond direct engagement in specific activities with specific people. It places the negotiation of meaning in the context of our forms of membership in various communities. It is a constituent of our identity" (Wenger, 1998: 57). Wenger views learning as a social practice. From Wenger's (1998) perspective, practice, rather than traditional teaching, define how we learn.

How to view learning is further challenged by Illeris (1999). Illeris (1999) claims learning embraces the results of the learning processes, the cognitive processes taking place within each individual, the social co-play between the individual and his/her material and social surroundings, which includes interaction with different types of media (e.g. a book, a tape, a computer), and finally learning as synonym for teaching.

Furthermore, in product development processes learning are related to practice. In a practice, individuals learn through practical examples from someone with more experience (Josefson, 1991). As the novice gets experience from participating in practice, the novice acquires a language that has meaningful content for her. Moreover, participation in a practice enables a language to develop, which provides a tool to describe what certain concepts mean in a given context (Josefson, 1991). Different people in the same setting will have different practical experiences depending on whom they have socialized with in that practice (Josefson, 1991).

The language developed by the participants in their common product development practice describes their processes of organisational learning. A study of their language reveals what their words mean, what employees do when using particular words and find the reasons for why they do something in a particular way. Since, peoples' experiences fill words and descriptions with content, it is necessary to interpret peoples' descriptions to understand how they do things, how they discover things, and how they experience a particular situation (Josefson, 1991). Theories need to relate to practice otherwise they will be useless in explaining what happens in practice (Josefson, 1991).

Moreover, if we through our investigation of practice only focus on finding answers to the how-questions, we are focusing on how practice solve a problem by using an if-then way of approaching the problem. If-then-loops give a limited set of solutions, and can easily exclude further solutions (Josefson, 1991). Josefson suggests that the why question is better suited to understand peoples descriptions of what happens in their practice. To understand what is learned, focus needs to be on the why-questions instead of the how-question (Josefson, 1991).

Subsequently, to recognise the value of knowledge and apply it strategically requires knowledge elicitation and questioning. Through questioning, it is possible to respond to what is being said, to describe the shared experiences, and to describe how to apply them. Nevertheless, it is necessary to interpret knowledge if it is going to be

usable. Interpretations are the individuals' verbalizing of what they do (Josefson, 1991). When participants' in product development describe their practice, they give an account of how their learning within the organization has taken place.

These different definitions of learning show that learning is a sense-making process, involving some negotiation of meaning together with others and internalising within the individual, and made tacit (Easterby-Smith et al. 1999; Lave and Wenger, 1991; Illeris, 1999; Polanyi, 1983; Wenger, 1998).

The importance of these different perspectives on learning is that they affect how to manage knowledge. Within the knowledge management field the interest in learning is based on an "acknowledgement that learning could also occur in and be facilitated by a range of practices, values and activities embedded in work process" (Hislop, 2009: 92). This perspective on learning implies that learning can be facilitated via the creation of learning cultures where learning, reflection, debate, and discussion are encouraged (López et.al. 2004; Raz & Fadlon, 2006).

3.3 Knowledge Management of Organizational Learning

A popular view within management literature is the idea that organisations can learn and create learning organisations (Levitt and March, 1988; Senge, 1990; Huber, 1991; Easterby-Smith et. al., 1998; Gherardi and Nicolini, 2001). Organizations learn, not because they think and behave independently from the people working within them, but through the embedding of individual, and group learning in organizational processes, routines, structures, databases, systems of rule etc. (Hedberg, 1981; Shipton, 2006; Shrivastava, 1983). Within an organizational context, learning involves a mutual exchange between the learning processes at the individual, group, and organizational level (Antonocopoulou, 2006). Subsequently, organizational learning happens when insight developed by an individual or group has an effect on the organizational level by changing processes or structures (Hislop, 2009). However, even if learning occurs at the individual and group level in the organization, it might not produce learning at the organizational level (Ibid.).

Organisational learning seems to be a pre-requisite for innovation, and knowledge management plays a mediating role between organisational culture, structure, strategy, and organisational effectiveness (Zheng et al., 2010). Organisational learning represents the knowledge acquisition process, and knowledge management represents structure and measurement.

> "Overall, organisational learning is a joint designation that describes how an organisation handles its experiences and develops its knowledge. The

> characteristic of this attitude is that in order to acquire organisational learning, it is important to reflect on the contrasts and co-play between the competence potentials which is available in the organisation and how to use them in a learning perspective" (Rasmussen et al., 2001: 10).

In large organisations, the influence of customers, suppliers, and external cooperating partners increase complexity in the learning process (Rasmussen et al., 2001).

Furthermore, management literature are concerned with how organisational learning influence the capability and performance of a company, and how organisational learning develops the company's capabilities to enhance their innovation process and improves their business (Baker and Sinkula, 1999; 2002; Han et. al., 1998).

> "Organisational learning is the process by which the firm develops new knowledge and insights from the common experiences of people in the organisation and has the potential to influence behaviours and improve the firm's capabilities" (Jiménez-Jiménez and Sanz-Valle, 2011: 409).

Individuals who are able to acquire existing knowledge and to share knowledge within the organisation will contribute to innovation (Jiménez–Jiménez and Sanz–Valle, 2011). Moreover, to enhance innovation and to affect performance positively the company develops capabilities from organisational learning (Baker and Sinkula, 1999, 2002; Han et. al., 1998; Hurley and Hult, 1998).

Five stages of organisational learning positively affect the company's performance: 1) information acquisition, 2) information dissemination, 3) shared interpretation, 4) declarative memory and 5) procedure memory (Tippins and Sohi, 2003). Moreover, when a company goes through these stages it is learning (Tippins and Sohi, 2003). Learning makes companies better in adjusting to market trends (Day, 1994; Sinkula, 1994; Tippins and Sohi, 2003). According to Tippins and Sohi (2003), organisational learning positively affects performance. Darroch and McNaugton (2003) provide evidence showing how the whole process of organisational learning produces better performance.

So far, the presented knowledge management literature demonstrates how to manage organizational learning in order to boost performance in the company. Nevertheless, there is reason to believe that organizations are not completely rational in their behaviour, and therefore that there is no straightforward path from knowledge management and promotion of learning in the company. According to Brunsson (2000), if organisations can learn such a claim is irrational. In the irrational organization, "there

is no automatic link between thought and action" (2000: p.18). Moreover, organisational actions deviate from a rational reflection and evaluation of the situation (Brunsson, 2000). Brunsson (2000) presents the following reasons for an irrational behaviour in organisations:

1. Information bias – decisions are often based upon biased information about a biased set of alternatives. Only the perceptions of a few organisational members form the basis for decision– making. Moreover, leaving numerous perceptions unexploited is reducing the multiplicity of perceptions to consider.
2. Thinking is not adapted to the purpose of action – It is necessary to reflect upon what problem the action is going to solve before executing it.
3. Problem of choice – Relates to finding out what to do and to do it.

Organisations facing difficult choices tend to formulate ideologies where the various activities leading to a specific action concentrate on creating expectations, motivation, and commitment (Brunsson, 2000). Therefore, when organizations behave irrational the behaviour within the organizations is regulated purely according to rules with little learning going on.

3.4 Tensions relating to Organizational Learning

The view that organisations can learn causes tensions within organisation learning and knowledge management studies.

One tension is the normative vs. empirical perspective on organisational learning and change (Agryis and Schön, 1996; Easterby-Smith, Snell, & Gherardi, 1998; Robinson, 2001). Normative approaches to organisational learning focus on strategies and prescriptions for organisational improvement and generally take up issues related to the goal of creating the learning organisation (Gavin, 1993; Senge, 1990). Empirical approaches focus on descriptions and analysis of organisational learning processes including issues concerning the value of such learning (Vince, 2001).

A second tension in the literature on organisational learning is the various conceptualizations of the role of the individual and the collective(s), and the contribution these make to learning, development, and to change processes in the organisation (Lehesvirta, 2004). Typically questions such as:

> "in what sense do organisations learn? To what extent, and through what processes does individual learning affect the organisation? To what extent and through what processes do the characteristics of organisations affect individual learning? deal with the individual and collective(s) contribution to organisational learning"(Peck, Gallucci, Sloan and Lippincott, 2009: 17).

The scientific debate on the nature and direction of organizational learning in relation to the individual and the society (the collective), also touches upon a great deal of social theory (Berger & Lukmann, 1966; Bourdieu, 1977; Bronfenbrenner, 1979; Vygotsky, 1978; Bahktin, 1981; Giddens, 1984). Furthermore, influences between the individual and society relate to issues within the field of sociology (Giddens, 1984; Sewell, 1992) anthropology (Lave, 1988) and psychology (Vygotsky, 1978). The issues concerning the individual and the collective(s) have promoted a research development towards transaction and co-evolution, and where changes in one constitute resources and conditions for changes in the other (Boreham & Morgan, 2004; Billett, 2006).

A third tension, considers the content of acquisitions versus participation metaphors for understanding the learning process (Lave and Wenger, 1991; Anderson, Reder & Simon, 1997; Greno, 1998). A focus on acquisitions represents an interest in the way individual learners develop their cognitive skills and their underlying mental processes (representations) (Anderson, et. al., 1997). The use of concepts such as search, retrieval, and sort in the literature on organisational learning extends the acquisition metaphor (Honig, 2008; Huber, 1991). Easterby-Smith et al. (1999) support the acquisition view by defining it as the technical view on organisational learning. A technical view on learning describes how to respond to and process information from both inside and outside the organisation in an efficient way (Easterby-Smith et. al., 1999). The participation metaphor defines learning as a socially negotiated process of change happening as individuals participate in cultural practices (Lave & Wenger, 1991; Rogoff, Baker-Sennet, Lacasa & Goldsmith, 1995). The participatory view expands organisational learning into constructs such as relational practices (Boreham & Morgan, 2004), expansive learning (Engeström, 1987; 2001), and communities of practices (Wenger, 1998). The participation metaphor reflects how learning and change essentially are isomorphic processes involving the social negotiation of meaning (Lave, 1993). A participatory metaphor views organisational learning as a social process where people make sense of their work experiences, and learns from them through social interactions. An overview of the factors influencing learning in organizations is shown in table 6.

Table 5: Factors influencing learning in organizations adapted from Hislop (2009: 106).

Factor	**Level**
The emotional character of learning	Individual
Competency traps and the difficulty of giving up established values and practices	Individual/group/organization
The politics and power involved in implementing learning and challenging established norms	Individual/group organization
The inter-relatedness of learning, knowledge and power	Supra-organizational
The embeddedness of power in the employment relationship	Supra-organizational

As table 5 shows, the different factors influencing learning affect the individual, group, organization, or supra-organizational level.

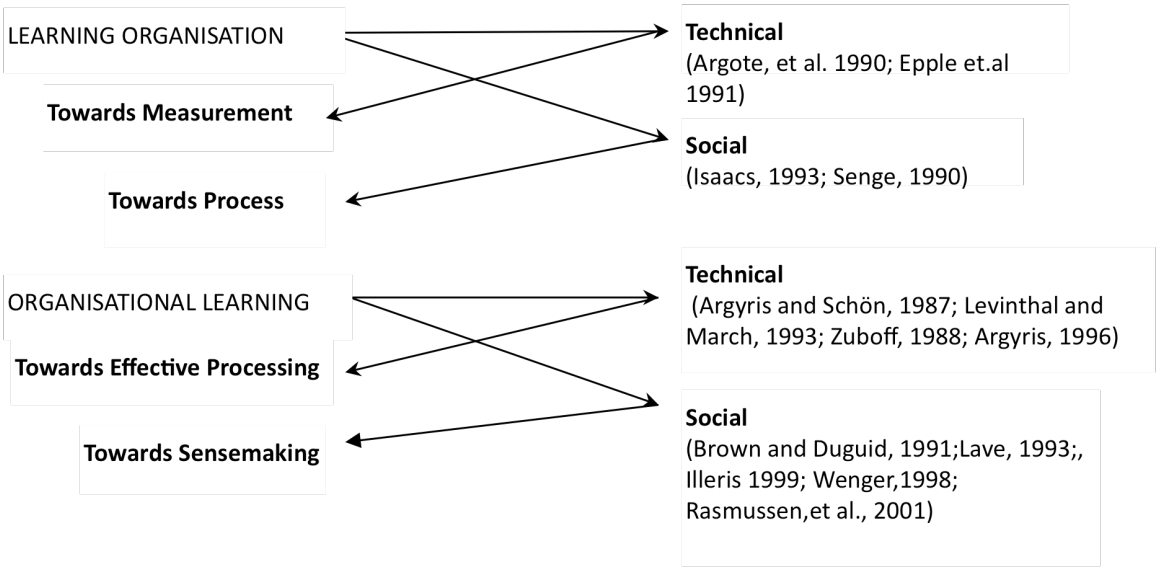
Three additional perspectives on organizational learning see learning as socially constructed, as a political process, and as implicated within the culture of the organisation (Easterby-Smith et. al., 1999).

1. Seeing learning as socially constructed emphasizes the fact that data has no significance in its own right, unless people determine what they mean. Therefore, people have to engage in a sense-making process.
2. Researchers who look at organisational learning from a political perspective, focus on how learning as social interaction will be influenced by peoples' interests. Moreover, a particular interpretation of information will suit some peoples' interest while harming others (Easterby-Smith et. al., 1999).
3. Looking at organisational learning from a cultural perspective sees learning as something that takes place when people interact, and becomes apparent when people work together with others. Normally, newcomers learn a particular behaviour, as they become members of a community through socialisation going from legitimate peripheral participation to full participation (Lave and Wenger, 1991; Easterby-Smith et. al., 1999).

Another way to look at organizational learning is the division of the field into learning organizations and organizational learning. The learning organisation concept

aims towards an organisation design for learning. Learning organisations primarily develop models and methodologies by focusing on creating change by improving the learning processes (Easterby-Smith et. al., 1999). Figure 3 below gives an overview of the different theoretical contributions to the field of organizational learning and learning organizations.

Figure 3: Theories Contributing to Learning Organizations and Organisational Learning extracted from (Easterby-Smith et. al., 1999: 3-10).



As figure 3 shows both the literature on learning organizations and organizational learning are split in two traditions technical, and social.

Within learning organizations literature, the focus is on using "specific diagnostic and evaluative methodological tools which can help to identify, promote, and evaluate the quality of learning processes inside organizations" (Easterby-Smith, 1999: 2).

Within organizational learning literature, the focus is on "observation and analysis of the processes involved in individual and collective learning inside the organization" (Easterby-Smith, 1999: 2).

Furthermore, the literature on organisational learning seems to view the terms learning and change as both cause and consequence of each other (Peck, et. al., 2009). A more classical approach to organisations sees change as a conscious and rationally administrated process run by management as economic calculations. However, as early as the mid-1950s, March and Simon (1958) described change as being incremental and unsystematic.

One important contribution is Arrow's (1962) analysis of learning-by-doing, where he demonstrated that the efficiency of a production unit engaged in producing complex systems increased with the number of units already produced, and therefore should be seen as a reflection on experience-based learning. He stated, "Income per capita cannot

be explained simply by increases in the capital-labour-ratio" (Arrow, 1962: 155). Accordingly, he claimed that learning is the product of experience, and learning can only take place through the attempt to solve a problem and therefore only takes place during activity.

Rosenberg (1982) took this perspective further, by introducing learning-by-using to explain why efficiency in using complex systems increased over time. From this perspective, fast technological development, and product development makes it harder to use the classical organisational models, because innovation capability and creativity need to be in focus. Building an innovation capability poses different requirements to managers and employees. The employee's attitudes, competencies, and networks become central in relation to the amount of resources employees bring into the company. Therefore, it is necessary to look at how knowledge management relates to technological innovation.

3.5 Knowledge Management of Technological Innovations

Innovation includes a technological development of an invention and an introduction of that invention to customers/end-users based on adoption and diffusion (Garcia and Calantone, 2002). Iterative innovation starts with a "first introduction of a new innovation and the reintroduction of an improved innovation" (Garcia and Calantone, 2002: 112).

According to Dogson (2000), managing technological innovation involves six areas: 1) R&D, 2) new product development, 3) commercialization of innovation, 4) operations and production, 5) technological collaborations and 6) technology strategy. He claims management of technological innovation is complex and risky, and therefore companies trying to develop organisational competitiveness in innovation, need knowledge management and organisational skills in order to learn fast.

Innovation is less a question of using the latest cutting-edge technology, and more a question of developing creative solutions in the company (Hildalgo and Albors, 2008). For Hildalgo and Albors (2008), IMT (Information Management Tools) represent models to promote creative solutions, and to handle technological innovations in a company. IMT techniques and models help companies to adapt to new circumstances and to meet market demands.

Hildalgo and Albors (2008) define 10 IMT typologies of corresponding models. Their study shows no one-to-one correlation between the company's specific business problem, and the methodology that solves it. Since, solving different business problems happen with a whole toolbox of IMTs. According to Hildalgo and Albors (2008: 118)

> "An innovation management technique cannot be considered in isolation. Normally, measuring the usefulness of one IMT for a particular business challenge happens by combining the IMT with other IMTs. By combining different IMTs they are adapted to each specific case they intend to solve. The benefit gained by the company depends on a combination of IMTs and the firm itself, and the mix of these two elements is what determines an effective outcome. To achieve the best fit between an IMT and the company, an understanding is needed of the firm and its business".

Companies applying their knowledge to improve their business internally, and to improve their external relationships with actors, result in a growth of IMTs (Phaal, et. al., 2006).

From the perspective of Jiménez-Jiménez and Sanz-Valle (2011), innovation transforms and exploits existing knowledge and gives business performance a boost. Innovations result from an organisational learning process, as knowledge is developed, acquired, transformed, and exploited (Jiménez-Jiménez and Sanz-Valle, 2011). Most studies on innovation define it as "adoption of a new idea or behaviour" (Jiménez-Jiménez and Sanz-Valle, 2011: 408).

Surviving in a competitive and turbulent environment requires adoption of new ideas or behaviour "one of the key drivers of long–term success in business" (Jiménez–Jiménez and Sanz–Valle, 2011: 409). In a turbulent environment companies innovate and respond to challenges faster than non–innovative companies (Brown and Eisenhardt, 1995: Miles and Snow, 1978). To innovate companies need an adaptive behaviour, and an adaptive behaviour depends on organisational learning.

Further, product development processes need to be carefully designed in order to reduce development time, create better products, and manage the risks of brining new products to the market (Unger and Eppinger, 2009). The risks necessary to manage in order to achieve success with product development can be split into four:

1. Technical risks – deal with uncertainty related to whether a product is technologically feasible, perform as expected, given clear and valid product specifications
2. Market risks – deal with whether a product meet customers needs, and are competitive.
3. Schedule risks – deal with whether a product can be developed in the available time.
4. Financial risks – deal with whether a product can be developed within the available budget and pay back the investment (Ibid.).

According to Unger and Eppinger, different product development processes (PDPs) will address risk through product development iterations, integrations, and reviews.

3.6 Knowledge Management in a Macroeconomic Perspective

Studies within innovation, industrial development, and international competitiveness produced the concept of National System of Innovations (NIS). Theory within NIS represents a new set of analytical concepts in contrast to traditional neo-classical economic theories. Within NIS, interactive learning and innovation are the core elements of economical analysis, and the theorists within this field claim that "the most fundamental resource in the modern economy is knowledge, and accordingly that the most important process is learning" (Lundvall, 1992: 1).

Lundvall (1988) introduces the concept of learning-by-interacting. This concept explains how interaction between producers and users in innovation enhances the competence of both and increases re-alignment and innovation by establishing closer relationships with collaborating partners. According to Lundvall (1988), well-established network relations make it easier to sort and use the growing information flow coming from the outside and translate it into product development.

For Lundvall (1988) the innovation process is a complex interaction between research, design, production, and marketing, combined with interactive learning and co-operation between different actors at all levels of the economy. Lundvall (1992) defines innovation as a socially embedded process, which has to be understood within the institutional and cultural context in which it takes place. Interactive learning involves different types of learning and different amounts of social interaction (Johnson and Lundvall, 1994). An increase in learning happens through remembering, and a reduction in learning happens through forgetting. Moreover, a taxonomy specifying what knowledge is essential for innovation and economic performance emerges. Johnson and Lundvall (1994) propose the following taxonomy of knowledge of:

- Know-what
- Know-why
- Know-how
- Know-who

Know-what refers to knowledge about facts, and this type of knowledge is relatively easy to codify (Johnson et.al, 1994).

Know-why refers to knowledge about principles and laws of motion in nature, in the human mind and in society. This type of knowledge appears to be codified, but is often incompletely codified since it partly builds on personal skills (Ibid.).

Know-how refers to skills and how to do something. This type of knowledge is influenced by experience based learning and intuition, and will never be possible to fully codify (Ibid.)

Know-who refers to knowledge developed and kept within the boarders of the company or research team. This type of knowledge encompasses information about who knows what and who how knows what to do, including the capability to co-operate and communicate with others. Know-who is context depended and therefore difficult to codify. "Its character and usefulness depend on social capital in terms of trus, networks and openness" (Johnson et. al, 2002: 251).

Reading books and attending lectures provide knowledge of the type knowing-what and knowing–why. Gaining knowledge thorough practical experiences, and social interactions, results in knowing-how, and knowing-who (Lundvall, 1996). Nevertheless, learning occurs within an institutional framework, where routines, procedures, standards, and habits affect how learning happens (Lundvall, 1996).

Furthermore, technologies are products of the social and economic context they developed from and help to shape, and consequently technological transition is more than substitution of artefacts, it is a change from one techno-socio-economic system to another (Ekins, 2010). The term "technology-push/market-pull describes the way technologies are developed and diffused in society and suggests that technologies develop through basic and applied research and development (R&D), and through development and commercialization and thereby diffuse into society" (Ekins, 2010: 10).

The factors driving influencing a technology push process can be described as:

> "The principal drives are business and policy decisions including government investment in R&D, including the activities and interest of scientist and engineers, that cause the technology to be developed. The commercialization and diffusion processes are much more driven by consumer demand-pull in the markets which have been targeted or into which technologies will by then have penetrated to some extent" (Ekins, 2010: 10).

Throughout the development phases, a continuous learning from and feedback between the development processes help the product to successfully meet the market demands (Ekins, 2010).

Kemp and Foxon (2007) criticize the linear nature of the technology-push/market-pull model, and recommend the interactive chain-linked model developed by Kline and Rosenberg (1986). In their model research and knowledge creation, take place throughout innovation, product development, design, and marketing stages.

Technology-push and market-pull are important aspects of technological change, but they lack the social context where such changes take place. Therefore, technology-push and market-pull factors are insufficient concepts by themselves to explain the more widespread changes implied by the term "technological transition" (Ekins, 2010: 11). There is a need to embed technologies in a much wider view on the social and economic system (Ekins, 2010). It is here that the evolutionary approach to technology adopted by Freeman and Louça (2001: 121) proposes the co-evolution of the five semi-autonomous social subsystems: science, technology, economics, politics, and culture. Freeman and Louça (2001) do not explore the implications of their insight into the necessary co-evolution of these five-subsystems, according to Ekins (2010). Therefore these categories, he claims, need to be expanded both to a "physical dimension" covering issues such as production/storage /distribution, and a "socio-economic dimension" dealing with "the interests and drivers that push technical change along: entrepreneurs (and profits), consumers (and preferences), and public policy pressure" (Ekins, 2010: 12).

Ekins (2010) also refers to Geels' (2002) seven key dimensions of a socio-technical regime:

- Technology
- User practices and application domains (markets)
- Symbolic meaning of technology
- Infrastructure
- Industry structure
- Policy
- Techno-scientific knowledge

The element, user practices and application domains (markets), describes what kind of user market behaviour the producer needs to understand and apply to push technological development forward.

Lundvall (1985) defines producer dependencies as information about user needs used as input in the innovation process. The incentive to monitor users lies with the producer, but is not only a question of identifying user needs. Lundvall (1985) describes producer dependencies as a continuous process of gathering information that can lead to expansion to new user groups and new markets. When dealing with complex and changing technologies users will engage in a learning-by-doing process, and the experiences and the knowledge they gain is of crucial importance for the producer (Lundvall, 1985).

However, Lundvall (1985) could not foresee the enormous increase in information flow because of the developments within ICT and the Internet in particular. Today information is more readily available, and users are not some anonymous entity. In order to satisfy users, the producers select and sort the information they need to enhance

their products. Since, "the internet can be viewed as a general-purpose technology that gives rise to a wide array of new products, processes and services" it poses new and different demands to the producer-user-relationship (Christensen-Frøslev, 2003: 209). Being able to access information and respond quickly to customer needs is the driving force in collaborations in the distribution industry. Internet technology allows distributors to be more involved in design and development of products, and it allows customers to check availability of needed items at vendors, and fill in orders immediately. Furthermore, the Internet facilitates distributed collaboration between all groups within and between companies (Carlsson, 2003). The adoption of business-to-consumer ordering and purchase systems bring the consumer closer to the production, and the role of the conventional dealers diminish (Kwoka, 2001). Distributed collaboration provides a more open innovation system with information available on-demand at all times.

Because of the immense impact of the ICT technology, traditional industries face new opportunities and challenges. One such example is the automobile industry, which has experienced huge changes in terms of production, supply, and demands. Additional influences on the automobile industry result from the impact of a concurrent growing Chinese economy. Already in 1994, the Chinese government defined the automobile industry as one of their pillar industries designated to drive the national economy (Holweg, Luo, and Oliver, 2009). The challenges facing the automobile industry are the current prerogatives of the Chinese economy such as cheap production facilities, a low-cost work force in combination with an urge for new knowledge and technology.

In addition to serving as an example of the impact of ICT and Internet, the automobile industry is also a large user of welding. The automobile industry uses both electron beam welding, which gives deep penetration and requires fast high-cost welding equipment, and more sophisticated welding such as micro welding done by complex welding machines. Moreover, developments within the automobile industry will also affect the development of welding. Low cost, low level of education and large requirements to efficiency require welding equipment to be cheap, self-explanatory in use, and reliable. These requirements challenge the producers of welding equipment in terms of production costs, user-interface, reliability, and quality of welding.

3.7 Knowledge Management of User-Producer Relationships

Management of innovation emphasises the user-producer relationship where the innovation process is closer to its customers and helps to increase productivity. To increase productivity, a user-producer relationship requires productive cooperation with

suppliers, customers, and trade associations including adaption of production to market needs and a flexible company (Hildalgo and Alors, 2008). The learning processes involved during these relationships are feedback loops and codification of knowledge (Hildalgo and Alors, 2008).

Feedback loops can be single- and double-loop learning (Argyris and Schön, 1996). Single-loop learning changes the strategies for an action or the underlying assumptions for the strategies, though not the values that define that action. Double-loop learning continues where single-loop learning leaves off by changing strategies, assumptions, and values lying behind an action (Argyris and Schön, 1996). When Argyris and Schön (1996) talk about learning, they define learning as an inquired action. The performance of an action new to an organisation is the most decisive test of whether a particular instance of organisational learning has taken place. Whether organizational learning happens it is necessary to focus on two considerations. Firstly, that there exists a collective in the form of an organisation with members that learn from it, and secondly, that these members are able to carry out on behalf of the organisation a process of inquiry that results in a learned product (Argyris and Schön, 1996).

Another perspective on the user-producer relationship is the Open Innovation Perspective (OIP). OIP emphasises how companies look outside their organisation for new product ideas, intellectual property (IP), and even fully developed ideas (Chesbrough, 2003). In this way, the learning process connects with the world outside the company.

However, open innovation must be extended further according to Enkel, Grassman and Chesbrough (2009). According to Enkel, Grassman and Chesbrough open innovation consist of three processes:

1. The outside-in process based on supplying knowledge from the outside by integrating supplies, customers, and external knowledge sources.
2. The inside-out process where profits are earned by bringing ideas to the market, selling IP, and multiplying technology by transferring ideas to the outside environment.
3. The coupled processes where complementing partners through alliances, cooperation, and joint ventures jointly develop and commercialize innovations.

Enkel et.als' descriptions of open innovation pay no attention to the participants' interpretations of the innovation processes. Which I think is important to understand and include, in order to determine how well open innovation works.

According to a study done by Cooper and Edgett (2008) the most effective open innovation models were: ideas from partners and vendors, ideas from the external scientific community and ideas from start-up businesses. However, Cooper and Edgett

(2008) do not see any of the open innovation models as particularly effective as sources of new product ideas. Moreover, companies to some degree have always been open and their degree of benefits simply depends on their line of business (Ibid.)

Another critique towards the OIP comes from capital-intensive industries where products take a long time to develop and remain in sale for many years. In these industries, there are only a few companies in the world that produce the products, and these companies rely on IP rights and secrecy. Furthermore, outside ideas "don't really stick well here" (Cooper and Edgett, 2008: 5), and within some specific industries such as production of aeroplanes, outside collaboration is not a benefit. On the contrary, it introduces more challenges.

Partners and vendors bring in technical capabilities going beyond the producer's expertise and give an advantage for the producer. However, when vendors or partners are uncreative, this leaves the producer with few new ideas (Cooper and Edgett, 2008).

Despite the difficulties of collaborating with partners, vendors and users to innovate, a large amount of literature acknowledges users as valuable for the innovation process (Bogers, Afuah, Bastian, 2010). Users are neither one homogenic group nor do they engage with the producer in the same way (Bogers, 2010). Bogers et al. (2010) split users as innovators into two groups: intermediate users and consumer users. The first group innovates because "their knowledge is sticky and they expect to benefit significantly from using the innovation" (Bogers et al. 2010: 861). The second group innovates because they have sticky knowledge in combination with local knowledge. They expect to benefit "from using and possibly selling the innovation and from enjoying the innovation process" (Bogers et al. 2010: 861). Hence, for users to be innovators they need to bring in sticky and local knowledge.

Producers take advantage of users-as-innovators in two ways: users as post-implementation adapter, and users as source of innovation-related knowledge (Bogers et al. 2010: 864). The first group of producers has an incomplete design which users fit to their exact need and context. The second group of producers see the users as a source of the solution knowledge and user's needs as imperative for successful innovation.

Bogers et.al (2010) wants a more coherent theory to explain why users innovate.

> "A more constructive theory is necessary in order to include learning and information processing, resource-, capability- or knowledge-based view of the firm and evolutionary economic theory or some combination thereof" (Bogers et. al., 2010: 866).

The literature on users as innovators, see a "lack of theory or theoretical perspectives, in particular those related to theories in the management literature"

(Bogers et. al., 2010: 865). Understanding the locus of innovation namely the transfer of knowledge between a user and a producer, is important because it covers locating, evaluating, and assimilating information about users needs and integrate the needs with technical knowledge into products the users want (Cohen and Levinthal, 1990).

3.8 Knowledge Management of Product Development

Yli-Renko et al. (2001) has found that there is a positive relationship between knowledge acquisition and product innovation. Moreover, two major traditions split the field of product development research and innovation research.

The first is an economic-oriented tradition studying innovation and innovative capability from a macro perspective by analyzing "the differences in patterns of innovation across countries and industrial sectors" (Brown and Eisenhardt, 1995: 343).

The second is an organisational-oriented tradition studying innovation from a micro perspective that emphasizes, "how specific products are developed" (Brown and Eisenhardt, 1995: 343).

Both of these traditions identify the factors that influence successful innovation (Brown and Eisenhardt, 1995). Their main concern and the goal of their research is to identify the reasons and conditions that help companies succeed with innovation. Performance is their central issue. (Ibid.)

An organisational-oriented tradition studies the innovation process by focusing on product development-related processes inside companies and organisations, and can be categorised into three different approaches:

1) The rational plan approach
2) The communicative web approach
3) The problem solving approach

A rational plan approach prescribes how successful product development depends on careful planning and implementation of the plan with the support of a "competent and well-coordinated cross-functional team operating with the blessings of senior management" (Brown and Eisenhardt, 1995). The studies dominating the rational plan approach primarily gather data through questionnaires supported by interviews with strategically placed informants (Ibid.).

A communicative web approach prescribes a successful product development based on communication between the members of the development teams, and with key outsiders (Brown and Eisenhardt, 1995). Studies within the communicative web approach indicate that both external and internal communication is critical for the success of product development (Brown and Eisenhardt, 1995). The dominant models used in this approach are multiple informants, multivariate analyses, and tighter

constructions (Ibid.). One criticism towards the approach is negligence of factors influencing product development such as organisation of work, product attributes, and market attractiveness. Research within this stream does not distinguish among different types of products, e.g. incremental versus breakthrough, versus platform products (Brown and Eisenhardt, 1995: 358 – 359).

A problem solving approach prescribes that successful product development depends on "autonomous problem solving by the project team and the discipline of a heavyweight leader, strong top management and an overarching product vision" (Brown and Eisenhardt, 1995: 359). The results of studies grounded within this approach demonstrate how to do product development faster with a high-quality product concept, and empirical data is gathered through in-depth case studies. Criticism against this approach is the "lack of political and psychological realism", that the concept used to explain the successful factors can be difficult to comprehend, e.g. subtle control, product vision and system focus. An additional criticism is its heavy reliance on a Japanese viewpoint stemming from the strong influence from Japanese research on this approach (Brown and Eisenhardt, 1995: 65).

Structuring the product development process into phases reduces risk, and risk control becomes an important part of conducting a successful product development. The belief is that structuring the product development process will provide the means to reduce the risk of failure and speed up throughput caused by the better integration of people and artefacts. Support for this is found in the work of Denker, Steward and Browning (2001) and in Mikkelsen and Hein (1989) in which they state "assumptions are among the greatest sources of projects risks. Making assumptions and their dependencies explicit is the key to controlling risks" (p. 31).

However, behind all activities of product development lay decisions. Krishnan and Ulrich (2001) establish a theoretical description they call "decision perspective" (p. 3) to explain how it is possible to get inside product development without too much concern on how decisions are made and to get an opportunity to generalize and develop a more grounded theory. They claim in their "decision perspective" that how products are developed differs across companies and within the same company over time, but what is being decided remains fairly the same at a certain level of abstraction (Ibid.). In their literature review article Krishnan and Ulrich (2001) go through 200 research papers in the period 1988-1998 and identify 30 major decisions made within product development organisations. The overall result of their literature review shows two different groups of decision during product development projects: 1) Decisions within a single project and 2) Decisions in setting up a project.

Decisions within a single project can according to Krishnan and Ulrich (2001) be divided into four categories: concept development, supply-chain design, product design, and production ramp-up and launch.

Decisions related to setting up a project is split into three categories: product strategy and planning, product development organization, and project management (Ibid.).

By organizing product development decision into these two groups Krishnan and Ulrich, are able to provide a description of how product development decisions are made by default and not by intention. Furthermore, they are able to provide an understanding of how the product development process is pushed forward by decisions.

3.9 Trust in Learning Processes

Trust must be part of a discussion concerning what elements make a social practice happen. It is the hidden pillar of social practice, and without it, knowledge sharing cannot occur. According to Karen Jones (1996) trust consists of two elements: 1) a cognitive and 2) an affective. "Optimism about the goodwill and competence of another" make us trust in others in the conditions for such a trust is part of our cognitive understanding (Jones, 1996: 7). The affective element of trust defines how emotions "are distinctive ways of seeing a situation" (Jones, 1996: 11). For this reason, the affective element makes "one's willingness to rely on the other seems reasonable" (Jones, 1996: 11). Moreover, the affective element defines the individuals' expected for establishing trust.

Creating trust depend on trustworthiness (Hardin, 1996: 29). Hardin's ideas about trust come from the political science field and are part of an institutional perspective. Acting in a trustworthy manner depends on an individual's commitment and interest, and can be supported by a "network of laws and conventions" and by a self-interest in "maintaining particular relationships" (Hardin, 1996: 42). However, any discussion about trustworthiness deals with a relationship between two individuals (Hardin, 1996). From the explanations provided by Jones (1996) and Hardin (1996), we can infer that trustworthiness builds on goodwill, competence, commitment, and interest, but that laws, conventions, norms, and rules can back that trustworthiness.

Figure 4: Illustration of factors influencing trustworthiness

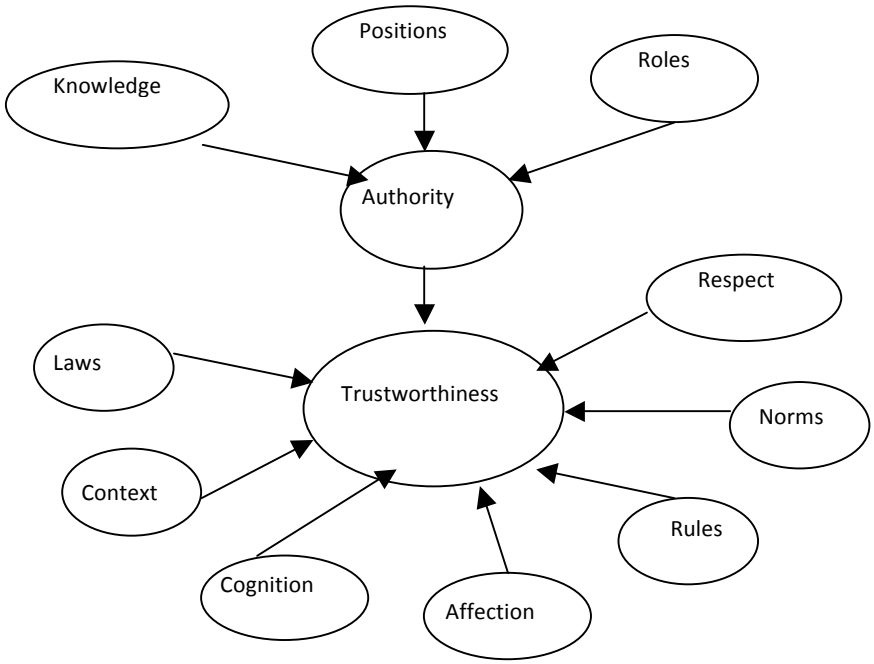


Figure 4 illustrates some of the factors that influence trustworthiness. Authority relates to positions, roles, and competencies. People hold formal positions within an organisation, and they are assigned to roles. A person can have many roles, but only one formal position. For example, a person can act as a project member in one project and a project leader in another, but his formal position can be that of mechanical engineer. The context element in figure 4, defines the surrounding institutional circumstances of trustworthiness. Context represents the conditions for displaying competencies. Cognition is how we perceive the other based on their conduct. Affection influences how persons feel towards others and decide whether they trust others, regardless of any guarantee given about a person's trustworthiness. Trustworthiness is not given it is earned.

Why is trust an important element in the innovation process? One answer could be that trust is one way of "reducing uncertainty or to adapt to unexpected contingencies" (Bstieler, 2006: 57). We tolerate uncertainty based on our expectations to a trusted person, who we trust will work or agree to reduce our sense of vulnerability to unpredicted contingencies (Blois, 1999). As a result, our confidence increases because we believe others will act proactively in any case where they need to adapt to unforeseen contingencies arise (Blois, 1999). According to Bstieler (2006), trust is the anticipation that others will act to serve or at least not act detrimental to our interests. Therefore, trust is a

social process and relates to the perceptions held by one party about another party's abilities, expertise, knowledge, motives, or intentions (Lewis and Weigert, 1985; Wilson and Möller, 1995).

According to Bstieler (2006), trust is not commandable, but is an outcome of a gradual and consistent effort over time evolving because of a growing knowledge and understanding of people with whom one must interact, in addition to the actual experience of interacting with that party. Individuals within organisations and their interpretation of colleagues' actual or likely behaviour are crucial to the establishment of trust (Blois, 1999). Bstieler (2006) claims that trust allows social interactions to proceed on a simple and confident basis, and the amount of trust existing within a group of people greatly affects the results they can achieve together. Hence, individuals who trust each other are more likely to share ideas and relevant information and to clarify problems. Despite these claims, there is little evidence to support a positive relationship between trust and performance in certain settings (Aulakh, Kotabe and Sahay, 1996; Dirks, 1999).

Innovation as a social practice takes place in distinct contexts, each with their separate demands. Employees participate in such a way they see their practice as meaningful. How well it works depends on the presence of trust between the participants. A meaningful practice involves trust in the process by those performing it, trust between the individuals in the process, and trust by those who stand to benefit from the process.

3.10 Social Capital

If norms, rules, and obligations influence learning, then these factors also govern the actions performed by a socialized actor. According to Coleman (1988), action is not entirely a product of an environment nor is it separate from it. In his rational perspective, "each actor has control over certain resources and interests in certain resources and events then social capital constitutes a particular kind of resource available to an actor" (Coleman, 1988; 98). Therefore, Coleman (1988) defines social capital by its function and unlike other forms of capital, social capital is inherent in the structure of relations both between and among actors.

Social capital

> "is not a single entity but a variety of different entities with two elements in common: they all consist of some aspect of social structures and they facilitate certain actions of actors – whether persons or corporate actors –within the structure. Like other forms of capital, social capital is productive, making possible

the achievement of certain ends that in its absence would not be possible" (Coleman, 1988: 98).

Coleman (1988) defines human capital as created by changes in persons where skills and capabilities develop and allow them to act in new ways. In contrast to social capital, a change happens in the relationship among persons who facilitates the action. His idea bases social capital on social relationships and an agreement between actors. For Coleman (1988), social capital manifests itself in relationships through norms, expectations, trustworthiness, and sanctions. Hence, Coleman (1988) claims social capital as created through social relationships established through family bonds.

Coleman (1988) also differentiates between tangible and intangible resources. Where capital is wholly tangible and embodied in an observable material form, human capital is less tangible and embodies itself in the skills and knowledge acquired by an individual, and social capital is even less tangible as it embodies in the relations among persons.

3.11 A Schematic Overview of Organizational Learning

This chapter has presented a broad spectrum of definitions and views related to organisational learning. Table 6 below summarizes these views.

Table 6: Knowledge management issues within the presented literature and for the welding industry

Theme	**What is it?**	**How is it done?**	**Why?**	**Who benefit?**
Knowledge Management	Control and manage knowledge	Scientifically – quantify and measure or Practice-based – work activities and practices	To provide the needed knowledge at the right time	Management
Knowledge Management of Learning	Facilitating individuals sense-making processes	Negotiation and internalising	To facilitate learning through creation of learning cultures	Individuals
Knowledge management of Organizational Learning	Facilitating organizations ability to learn	Focus on experiences and knowledge in order to change routines and procedures	To improve the capability and performance in the organization	Individual, group, organization
Organizational Learning tensions	Organizational processes affecting individuals learning	Prescriptions, change processes, transactions, co-evolution, acquisition versus participation	Influence negatively individuals ability to learn and to contribute, to the organizational learning	None
Knowledge Management of Technological Innovations	Adoption and diffusion of an invention	Transforms and exploit knowledge to promote business performance	To survive in a competitive environment	Management
Knowledge Management in Macroeconomic Perspective	Impact of science, technology, economics, politics and culture on the innovation process	Continuous learning and feedback between the development processes and the outside of the company	To understand how the outside (world) affect the innovation process	Management
Knowledge Management of User-Producer Relationships	The learning process connects with the world outside the company	Collect ideas from partners and vendors	To succeed in the market with the products	Management
Knowledge Management in Product Development	Manage development of products	Coordinating processes inside and outside the company	To make sure the product development process succeed	Management, users, customers
Knowledge Management Challenges in the Welding Industry	Impact of knowledge on development within welding	Focus on technological development to cope with the challenges	To survive as an industry	Management, users, customers

Table 6 illustrates the main characteristics defining aspects related to knowledge, and learning within the different theories presented in this chapter. These different perspectives do not exclude each other, but are complementary perspectives.

This chapter demonstrates, that knowledge management theory and organizational learning theory are tightly woven together. Furthermore, that the field of knowledge management has grown in diverse directions, but discussions about what counts as learning are seemingly rare. In our language lies the key to define what one's personal knowledge is, compared to that of others. However, to understand what knowledge individuals have there need to be more focus on why-questions. The why-questions provide us with explanations to why things are done in a particular way. The why-questions need to supersede the how-questions. The focus should be on what questions to ask within an organisational setting, by whom, and how to answer these questions and what are the implications of the answers. The key lies in the language used by the participants in the innovation process. Therefore, the empirical investigations in this thesis use the explanations and language of participants to understand their organisational learning. (Chapter 4 and 5 present a summary of the empirical analysis, and Appendix IX presents the complete analysis.)

4. Empirical Data Selection and Research Challenges

This chapter discusses the selection of data, the interpretation of data, and the use of grounded theory (GT) as an inspiration for the applied research method. Moreover, it explains how the research process helps to grasp the outcome of the data analysis.

4.1 Selecting the Empirical Data

The data used in my research, is a study of a product development team in a Danish welding machine manufacturing company. The company was selected from the DISKO module-2 database. DISKO, is an acronym for the Danish Innovation System in a Comparative Perspective, a three-year project (1996-1999) headed by Professor Bengt–Åke Lundvall and financed by the Danish Business Development Council.

The DISKO database sorts companies into different categories, using a model by Keith Pavitt (1984). In his model, Pavitt (1984), sorts companies across various industries according to their different innovative characteristics. He splits the industries the companies belong to into four sectors according to their patterns of innovation as follows:

1. Supplier dominated - Supplier dominated companies belong to the textile and clothing industries or the paper, wood, and furniture industries. These industries use innovations developed outside their sector.
2. Scale intensive - Scale intensive companies belong to the food, consumption, paper, and graphics industries. The characteristics of these industries are large production series of standard products.
3. Specialized suppliers - Specialized suppliers such as the machine industry are often small and advanced companies working as suppliers to other companies. These companies have high innovation capabilities.
4. Research oriented - Research oriented companies such as companies within the chemical and electronics industries. The research-oriented sector is the most innovative of these four sectors, and companies within this sector have large research and development departments and collaborate with research institutes (Pavitt, 1984).

After identifying the companies using Pavitt's categories, the number of companies was narrowed down by applying two additional selection criterions. First, only companies developing more than one new product within the last three years using one man–year or more, or one major project lasting six months or more within the last three

years, were selected from the database. Secondly, only those companies having between 50 and 500 employees would be included in the final data set.

After having exposed the DISKO database to these additional selection criterions, a list of approximately 50 companies was produced. After the first rounds of contact with these 50 companies, we ended up with a list of 11 companies. The 11 companies were: three machine companies which belong to the specialized suppliers, two electronics companies belonging to the knowledge intensive companies, one metal company, one rubber/plastics company belonging to the scale intensive sector, one furniture company belonging to the supplier dominated sector, and three companies within the business service sector (Lund, 2001). All of these 11 companies were interviewed. However, a few withdraw from our research project for various reasons at different points during our research process. A complete list of companies and their reasons for withdrawing from the research project is shown in Appendix I.

From the group of 11 companies, I selected one of the specialized suppliers from the machine industry, a welding equipment manufacturer (Lund, 2001). Why this company was selected is described in section 4.2.

4.2 The Selected Company

The data used in my thesis comes only from the machine industry company B, a welding equipment manufacturer (see Appendix I). Pavitt's (1984) classification defines this company as a specialized supplier.

My reasons for choosing this welding manufacturer were:

1. The welding machine manufacturer is a market leader within the industry. Moreover, I assumed this would influence degree of professionalism, knowledge level, and competence in the innovation process.
2. The company came across as willing to participate in this research project, by opening up their core innovation activities for exposure, and by agreeing to consecutive visits by the research team.
3. The total amount of data acquired from the interviews soon proved to be rich and extensive. This was not the case for the other 10 companies (see Appendix I).

The welding machine manufacturer is a world market leader within the welding machine industry. The company assembles welding machines and have approximately 400 employees while its development department consists of approximately 60 employees. (These numbers refer to the situation in the company in 2000/01 when the data was collected).

The data from company B covers nine interviews undertaken with two interviewers at each interview, and with only one participant from the company each time. The main

interviewers were Professor Emeritus Reinhardt Lund and PhD student June Tolsby. In addition, Professor Jørgen Gulddahl Rasmussen and former PhD student Peter Biebygaard participated in two of the interviews.

The data consists of consecutive interviews over a 13-month period. During the 13-month period a product manager, a project manager, a production manager, a marketing employee, and a welder were interviewed. The studied product development project was visited four times, and based on an "in between" analyses of the data, the questions in the successive interviews were modified. By modifying the questions in successive visits to the company, the categories are better grounded in the data, and can provide a theoretical description of the product development influences.

Additional source materials that were available as documentation of the developed products were brochures and a few descriptions of the development model.

The total number of projects reported in the interviews is larger than the table displayed in Appendix I. During interviews, the informants recapitulated and included experiences from previous projects to illustrate their points. Even if we investigated a specific project by following the progression in the project, during the interviews employees report from many of the previous projects they have participated in. Therefore, during the interviews, the employees constantly presented experiences from other projects. This gives a much broader and richer picture of how they perceive their product development processes.

4.3 Challenges when Constructing Theory from the Empirical Data

The aim of my thesis is to develop a theory that can explain how employees' processes of organizational learning affect the structure of their product development process. The empirical data used to identify such a theory is based on analysing employees' explanations given in their interviews.

To be able to answer the research question, I found interviews to be the most adequate method to use for data collection, and not observations nor questionnaires. Interviews can provide more detailed information about employees' interpretation of their development work than questionnaires. Observations were not an option, because I was mainly interested in employees' interpretation of their work, and not how they perform it. Furthermore, I want to develop theory and found GT to be the most adequate method to choose.

Using GT, as an inspirational method, enables inductive derivation by studying a phenomenon. The theory develops through systematic data collection and analysis of data pertaining to the studied phenomenon. GT evolves through discovery, development, and provisionally verification. "Therefore, data collection, analysis and

theory stand in reciprocal relationship to each other. One does not begin with a theory and then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge" (Corbin and Strauss, 1990: 23). To understand how participants of product development interpret their work processes, their views needed to emerge, and GT is an applicable research model to use for that purpose.

GT aims to develop theory concerning "social life patterns" and it "has emerged from the symbolic interaction tradition of social psychology and sociology" (Annells, 1996: 380). With its bottom-up approach GT is in particular applicable to research questions with limited theory, or where the theories are only partially offering an understanding of the researched topic (Martin and Turner, 1986). Under these circumstances "the researcher will want to develop a theoretical account that facilitates discussion of the general features of the topic under study and is firmly based or grounded in the data collected" (Martin and Turner, 1986: 42).

A theoretical account, if it is carefully crafted, will enable the researcher to question existing theory, to better understand the explored area, and enable the researcher to communicate findings to those investigated (Martin and Turner, 1986).

The process towards a theory is to construct a model describing what happens in the studied field. A stringent explanation of how to define what qualifies to be called a theory can be found in A Brief History of Time by Stephen Hawking (1988). He claims that a theory, to be defined as a good theory, needs to satisfy the following two requirements:

1. Describe accurately a large class of observations based on a model containing only a few arbitrary elements.
   and
2. A theory must make definite prediction about the result of future observations. He states that any physical theory is always provisional, because as a hypothesis it can never be proved. However, a theory can be disproved if, according to Hawking (1988), a single observation that contradicts the predictions of the theory is found.

From a GT perspective the researcher engages in a process to construct categories. These categories describe what happens in the studied field, and together the categories give a theoretical account of the studied field. In contrast to Hawking's (1988) definition of a theory, the categories developed when using GT, should be used broadly to incorporate more studies. Where traditional theories will be disproven if a single observation contradicts the predictions of the theory, GT aims to include more and more data and by including more data, it will become a theory for the studied field. However, according to May (2009) to build theory within GT requires entwining a large-scale

study. A small study such as mine can therefore only provided hypothesis that needs to be supported by a lager study.

However, using Hawking's (1988) definition of a theory means using a definition developed within physics, and to apply this definition to a study within the social field. Although, one might claim that what qualify as theory, should have a universal definition independent of the research field.

A better approach is to expand the requirements to what qualifies as a theory within the social field. Therefore, I have chosen to use May's (2009) definition of a theory. He claims that theory needs to be seen as explanations formed through a set of four tasks:

1. "Accurate description. A theory must provide a set of definitions that enable the identification, differentiation, and codification of the qualities and properties of cases and classes of phenomena.
2. Systematic explanation. A theory must provide an explanation of the form and significance of he mechanisms and processes at work in cases or classes of the phenomena, and should propose their relation to other phenomena.
3. Knowledge claims. A theory must lead to knowledge claims. These may talk the form of analytic propositions, or experimental hypothesis. They may also map relations with other phenomena that are believed to possess similar qualities and properties.
4. Investigation. A theory must be testable. Such test may be abstract (i.e. formal logical representations, simulations, or thought experiments); or concrete (empirical investigations)" (May, 2009: 48).

According to May's (2009) following this definition, of what constitute a theory, will provide an "explanatory account of why those objects take the form they do and how they work" (p. 48).

However, the quantity of my empirical data is not large enough to be giving a sustainable theory. Therefore, my aim is only to provide a theoretical account of what happens in the studied company. Furthermore, by having only one case to use GT on, I develop according to May (2009) only theoretical explanations for action, rather than exploring networks or interrogating discourses. My claim is that I am not following GT stringently according to Glaser and Strauss (1999) version, but that I develop theoretical categories that need to be tested on new cases to become true GT. In order to be able to identify these theoretical categories, I analyse my empirical data by following Glaser and Strauss' (1999) scheme for developing theory:

Table 7: Table adopted from Glaser and Strauss (1999)

Elements of Theory	
Category	Knowledge Harvesting
Properties of Category	Gaining knowledge based on learning to identify knowledge lacks, gaining knowledge, controlling knowledge, and distributing knowledge.
Hypothesis	The more the company works with knowledge harvesting the more able are they to improve their ability to gain knowledge and move the product development process forward.

According to Glaser and Strauss (1999), the process towards generating theory should aim to achieve diversity in the emergent categories, synthesized as many levels of conceptual and hypothetical generalizations as possible. This process will, according to, Glaser and Strauss (1999), help to get connections between the data and lower and higher level of conceptual abstractions of categories and concepts.

4.4 Analysing Interviews

Qualitative studies using semi-structured and structured interviews, allow answers to be found by doing a purposely research on a well-formulated problem. However, interview guiding instructions focus on how to handle the interviews before and after the analysis, and pay little attention to the models needed to analyse and interpret the data (Hamersley and Atkinson, 1987: Yin; 1994). GT prescribes few instructions before a research process starts, but offers a stringent regime regarding the interpretation and analysis of the data.

Following a GT regime of analysis and interpretation opens the research process to outside scrutiny, and allows a more transparent investigation process. GT increases the outsiders' understanding of the analysis by showing how to achieve the research results.

My investigation of the empirical data appear as descriptions of a structured reality due to how the employees perceive and talk about their product development process. Participating in product development influences employees' behaviour, and how they build knowledge. In fact, it shapes how the participants become who they are. As I see it, experiences are recollections of episodes remembered by the individuals, which are difficult to observe. The experiences are historically accumulated comprehensions of product development. Moreover, the accounts enable an

understanding of employees' participation in product development, and the conditions, the reasons and the consequences of their participation.

Employees' descriptions give a picture of how employees' grasp product development, and the researcher needs to interpret the employees' experiences with caution. The employees' explanations represent informants' comprehensions at a certain point in time influenced by the organizational position, culture, and roles these informants play. Riessman (1993: 8) claims, "we cannot give voice since we do not have direct access to another's experience. We deal with ambiguous representations of it – talk, text, interaction and interpretation". An interpretative approach is unavoidable when researchers want to present an account of a studied subject or a studied object (Holloway and Jefferson, 2000). An important question posed by Holloway and Jefferson (Ibid.) is: "if experiences can only ever be ambiguously represented, is interpreting these various representations, rather than the experiences themselves, the only possible activity for researchers?" (Holloway and Jefferson, 2000: 3). Holloway and Jefferson (Ibid.) believe there is a relationship between people's ambiguous representations and their experiences. Moreover, they demonstrate how epistemology colours their view on how new knowledge is advanced.

A researcher's claims are a product of defined research goals (if they exists), the model used to arrive at the knowledge about the field under investigation, and the epistemological tradition, to which the researcher confesses (Bunge, 1993). Bunge (Ibid.) calls such an approach to research critical realism. Critical realism is a philosophical tradition that focuses on how our knowledge is created, through the way things appear for us, bearing in mind that things' appearance will change as our knowledge of things develop.

According to Sellars (1924), "the critical realist is simply more explicitly in his analysis and distinguishes more carefully between the conditions and instruments of *knowing* and knowledge itself. Though separable by analysis, these two processes are continuous" (Sellars, 1924: 382). The purpose of my thesis is to arrive at a new theoretical description of the product development process, and GT is an appropriate research model to use.

Riessman (1993) wants a stronger emphasis upon how talk transforms into a written text when analysing transcriptions of interviews. She requires a stronger focus on: what aspects of an interview constitute the basis for interpretation, and who determines what the empirical data mean and if alternative readings are possible. Riessman's (1993) discussion of limitations in narratives is an example of a more holistic approach to the analysis of texts opening up reflection on the results and data.

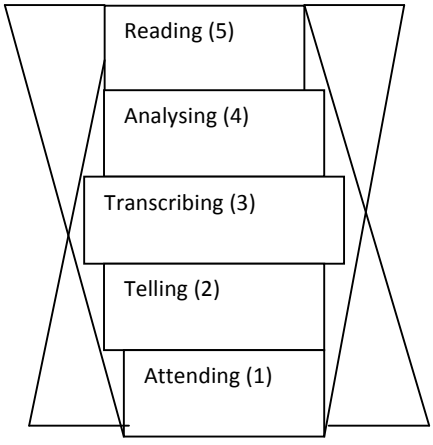
Riessman (1993) with her background in medical sociology and studies of individuals' real–life stories, is concerned with how to represent narratives in a text. The

analysis of narratives that "takes as its object of investigation the story itself" represents the core of her model (Riessman, 1993: 1). According to her interpretations, one should no stretch interviews too far, but pay attention to meaning and form to emphasize the story told and the role of the storyteller. Riessman advocates awareness when doing qualitative analysis since "traditional approaches to qualitative analysis often fracture these texts in the service of interpretation and generalization by taking bits and pieces, snippets of a response edited out of context they eliminate the sequential and structural features that characterizes narrative accounts" (Riessman, 1993: 3).

When discussing what constitutes a narrative, Riessman starts off by defining it as a "talk organized around consequential events" in which the storyteller takes the listener back to events in the past by recollecting what took place (Riessman, 1993, p.3). Riessman claims that a narrative primarily responds to the question "and then what happened?" However, she acknowledges that "all form of representation of experience are limited portraits", and even when the purpose is to "tell the whole truth", a narrative represent the writer's words (Riessman, 1993, p.15). A writer does both the selections and the new interpretations in a narrative. Consequently, Riessman (1993) emphasizes that researchers conducting qualitative research need to emphasis how they transform their empirical data, and she poses three generic questions the researchers ought to pay attention to: How is talk transformed into a written text? What aspects of an interview constitute the basis for interpretation? Who determines what the empirical data mean and are alternative readings possible? (Riessman, 1993: 25).

In an attempt to answer these questions, Riessman (1993) identifies a model consisting of four stages, which incorporates the steps interviews/narratives go through in order to transform the narratives into a readable text. Figure 5 illustrates the phases involved in such a transformation.

Figure 5: Levels of representation when processing research data adapted from Riessman (1993: 10)



Over time, new knowledge and new models equip us with a new set of tools for analysing data (Bloch, 1998).

4.5 Trust in Data

The challenge, when performing qualitative research, relates to being dependent on a responding and trustworthy individual willing to provide answers. In the studied company, the aim was to build a trustworthy relationship over time, through consecutive visits talking to the same persons on each visit. Whether we managed to establish such trustworthy relationships, is difficult to evaluate. However, as the research process moved forward my subjective experience was that we (as a research team) had access to the experiences and reflections of the central actors in the project group.

As a research team, we followed the project group participants over a period of 13 months, with recurrent visits to the company to collect data. As the data collecting proceeded, the interviewed actors included reflections from their participation in various projects. By including reflections from many projects, a multitude of experiences from product development projects emerged.

Focusing on a particular event or problem can help to ensure the correctness of the given information, such as one or two product development projects (see Appendix I for the projects in the studied company). When several people give their description of what took place during the process, differences in interpretations emerge, but some of the facts still match such as dates and specific products or end-results. Their descriptions can either confirm or disconfirm by additional sources of information. However, it was not possible to confirm information via secondary sources without revealing the identity of the company. To guarantee the company confidentiality the analysis uses no secondary sources.

The quality of the data rests on the participating employees perceptions and views on the product development process. Furthermore, the data interpretation process does not evaluate the facts, but present them as employees' views. In the interviews, respondents answer the posed questions and reflect over their answers. It would be a fallacy to delimit the categories due to the complexity in the interpretations. Therefore, to avoid loss of meaning the developed categories are broad. By writing out the categories participants' comprehension of their product development work emerge.

An example of the accumulative process is how the respondents in the first interviews talked about product committee meetings, and in later interviews talked about the product strategy group due to reorganization in the company during our

investigation. The company reorganized the development team from a large formal decision body called product committee, to a smaller decision body called the product strategy group.

To find answers on how employees' understandings influence product development, it is fundamental to sample, compare, and contrast individual's experiences over a certain length of time.

5. From Grounded Theory to an Approach Inspired by Grounded Theory

In this chapter the characteristics of doing Grounded Theory (GT) is explained by drawing mainly on the literature by Glaser and Strauss (1999), and Strauss and Corbin (1998). Furthermore, the central characteristics of some of the dominating GT approaches are presented. Finally, this chapter presents my approach to GT and illustrate this with an example of how to code the data.

5.1 Characteristics of Grounded Theory

Two streams of thought contributed to the development of GT namely American Pragmatism and the Chicago School of Sociology during the period 1920s to the mid-1950s (Strauss, 2003). It was a general belief in the 1920-30 that "the great men" (Marx, Simmel, Durkheim, Veblen, Weber and Mead) had created enough theory to explain areas of the social life to last for a long while (Glaser and Strauss, 1999). Therefore, many sociology departments at universities became repositories of "the great men" theories, teaching their students how to apply small parts of these theories.

Glaser and Strauss (1999) formulated and published their version of GT in their book, "The Discovery of Grounded Theory: Strategies for qualitative research", first published in 1967. Their intention was to describe a research methodology that would improve researchers ability to generate "theory that will be relevant to their research" (Glaser and Strauss, 1999: vii-viii.). Their motivation for developing GT was to narrow the gap between theory and empirical research. Such a motivation came from observing that sociologists and other social and behavioural scientists were mainly concerned with closing the gap between theory and research by improving models for testing theory (Glaser and Strauss, 1999: vii).

Restricting the use of a particular model to a limited area reduces the possibility for using the model "on social units of any size, large or small, ranging from men or their roles to nations or world regions"(Glaser and Strauss, 1999: 21). Such a restriction limits the use of the model to a specific class of social units to which it frequently has been applied.

Using GT is not only a question of generating new concepts and theory, but also a question of assigning new meaning to old categories. Similar for both approaches is the generic meaning categories gain, like a life of their own, independent of the context that gave rise to them. Strauss argues that the GT "approach to qualitative data is toward the development of theory, without any particular commitment to specific kinds of data,

lines of research, or theoretical interests. Therefore, it is not really a specific model or technique. Rather, it is a style of doing qualitative analysis that include distinct features, such as theoretical sampling and certain methodological guidelines, such as the making of constant comparisons and the use of a coding paradigm, to ensure conceptual development and density"(Strauss, 2003: 5).

5.2 Symbolic Interactionism

GT comes from a research tradition within sociology called symbolic interactionism a tradition pursuing the elements guiding human behaviour. "Symbolic interactionism" is rooted in the "Chicago School of Pragmatism". George Herbert Mead is viewed as the primary originator of the ideas that comprise the symbolic interactionist perspective. At the core of Mead's theoretical framework is "the proposition that human beings have a sense of self that we develop through interaction with others" (Locke, 2001: 21). It is our sense of the self that directs how we act and in what way we act towards objects in the world. Typically, the sense of the self as a "researcher" stems from those actions and interactions the self engages in.

Herbert Blumer, a former student of Mead, was the first to introduce the concept "symbolic interactionism" as a description of a distinct way of researching human group life and human conduct (Blumer, 1998). The "symbolic interactionism" research tradition focuses on studies of human group life, and emphasis how humans' reflect and make sense of their acts (Blumer, 1998). "Symbolic interactionism" emphasises what we do, and how we understand what we do, because this will colour our meaning, and meaning is an essential condition for all human activity (Blumer, 1998). According to Blumer, "symbolic interactionism" has three characteristics:

1. That people act towards "things" based on the meaning they have to them.
2. That the meanings people attach to "things" derive from a social interaction with others.
3. That meaning moulds in a reflective process as the individual deals with the "things" encountered (Blumer, 1998; 2).

"Things" cover relationships, organizations, beliefs, activities, situations, and objects (Blumer, 1998: 2).

Blumer (1998) defined six essential ideas on which "symbolic interactionism" rests, and these ideas describe how symbolic interactionism works in practice, as actions between humans.

His first idea defines humans engaged in action as a prerequisite for any human society or group life.

His second idea emphasises how social interaction between people defines group

life, and group conduct. Such group conduct is seen as "the matrix within which meaning arises" (Mead, 1967: 67). Furthermore, group conduct signifies what the person to whom a gesture is directed, is required to do, what the person who made the gesture plans to do, and the joint action that is to arise by the articulation of the acts of both (Blumer, 1998: 9). A gesture is "any part of or aspect of an ongoing action that signifies the larger act of which it is a part" (Ibid.).

The third idea describes how human group life through human conduct relates to different objects and the nature of such objects in their surroundings. Objects are classified in three ways:

1. Physical objects
2. Social objects
3. Abstract objects (Blumer, 1998: 10).

Physical objects can be a chair, a tree etc. Social objects can be a student, a friend etc. and, abstract objects can be ideas and moral principles. Blumer (1998) claims that within "symbolic interactionism", understanding peoples' world of objects, depend on understanding their actions. Therefore, "human group life is a process where objects are being created, accompanied, transformed and cast aside" and objects in peoples' worlds' get their meaning because of a social process (Blumer, 1998: 12).

The fourth idea sees the human being as an acting "self". Therefore, a human being as an acting organism, prepares an action on the basis of what he or she takes into account, and do not simply act in a stimulus-response kind of way, but in a reflective way (Blumer, 1998: 14-15).

The fifth idea Blumer (1998) presents, that influence human group life, are that a human being acts based on selecting what to take into account of the things she/he notices. Furthermore, the interpretations of these things form their conduct (Blumer, 1998:15).

Finally, the sixth idea defines human group life by seeing human actions as linked together (Blumer, 1998). Furthermore, a joint action between humans is connected to their activities, and their actions are linked both horizontal and vertical with their previous joint actions (Blumer, 1998: 20).

By defining these ideas of "symbolic interactionism", Blumer defines the fundament for an approach to the study of human group life that is "designed to yield verifiable knowledge" (Blumer, 1998: 21). He defines these characteristics to guide the researcher who does scientific inquiries within the empirical sciences.

5.3 Pragmatism

Historically, symbolic interactionism finds its origin in pragmatism and in the ideas of Emmanuel Kant. Kant (1798/1958) differentiated between what he called pragmatic and practical actions. Pragmatic actions (also called technical actions) have a goal and a calculation, and describe how the goal can be achieved using more or less verifiable experimental knowledge. Pragmatic actions are guided by means and goals and are successful when reaching the goal (Kant, 1798/1958).

When it comes to practical actions in the social field, Kant (1798/1958) claims that these are guided by universal norms. Kant calls the universal norms guiding our practical actions for "the categorical imperative". According to "the categorical imperative", our actions are governed by the principle that all others should be able to act in the way "I have acted" (Kant, 1798/1958). Kant's, "categorical imperative", constitutes respect for others when actions are done in the social field (Kant, 1798/1958).

Kant introduced a separation between things, and persons. He claimed that only in relation to things is a one-sided technical or pragmatic action legitimate. Kant states his moral philosophy, based on respect in the moral law (principle) and for other people. Pragmatism as a philosophical tradition is rooted in these Kantian imperatives.

Kant's view on pragmatism further developed into American pragmatism. American pragmatism was primarily developed by Charles Sanders Pierce, William James, John Dewey, and George Herbert Mead in their discussions to define what practical mean in relation to controversies, beliefs, ideas, and objects. Their work on pragmatism is called the Chicago School of Pragmatism.

For Dewey (1908), pragmatism should be applied as widely as possible, and to such a broad spectrum of human group life as possible including controversies, beliefs, truths, ideas and objects. He claimed that in relation to an object, meaning signifies conceptual content or connotation, and practical means the future responses, which an object requires of us or commits us, to do. He emphasised that a pragmatic idea is an idea, which is practical, and therefore has an intention.

> "When, then, it is a question of an idea, it is the idea itself which is practical (being an intent) and it's meaning resides in the existence which, as changed, it intends. While the meaning of an object is the changes it requires in our attitude, the meaning of an idea is the changes it as attitude effects in the objects" (Dewey, 1908: 88-89).

Hence, according to Dewey there is a linkage between ideas, objects, meaning, and action. He claimed that meaning would change resulting from changes in how we view an object and will influence the action we take with respect to that object. The action we

take, according to Dewey, will change our stance towards the object and will affect our meaning or understanding with respect to the object. Furthermore, Dewey claimed that objects, meaning, and actions are interrelated in a spiral–like process, continuously changing our view of the world.

5.4 Doing Data Analysis using Grounded Theory

An important feature of GT is how the researcher repeatedly goes back and forth between data analysis and doing interviews. The researcher refines the questions based on prior data collection, and in his/her consecutive interviews, he/she confirms certain categories detected in her first data analysis. Elaboration of categories happens as the researcher shifts between data analysis, and data collection. In this way, the researcher makes sure that the developed categories are grounded in the data (Glaser and Strauss, 1999).

When generating theory, the final categories emerge from the empirical data. The categories are theoretical abstractions of what goes on in the studied area. Hence, the data according to Glaser and Strauss (1999) only represent a fundament for building the theory. Once the theoretical abstractions are formulated, the original data is of less importance. Furthermore, they argue that even if the evidence for a particular abstraction is not entirely accurate, this is uncomplicated. When generating theory, it is the conceptual category, which is central, and not the fact used to generate the conceptual category. Therefore, Glaser and Strauss (1999) claim that a concept can be generated from one fact, and this fact only represent one of a universe of many possible diverse indicators, or facts, that points to the concept.

> "In discovering theory, one generates conceptual categories or their properties from evidence; then the evidence from which the category emerged is used to illustrate the concept. The evidence may not necessarily be accurate beyond a doubt (nor is it even in studies concerned only with accuracy), but the concept undoubtedly a relevant theoretical abstraction about what is going on in the area studied. Furthermore, the concept itself will not change, while even the most accurate facts change. Concepts only have their meanings respecified at times because other theoretical and research purposes have evolved" (Glaser and Strauss, 1999: 23).

According to Glaser and Strauss (1999), the life of the evidence generating the categories can be short lived, but the theoretical abstractions live on until they are proven obsolete for any class of data. In order to arrive at theoretical abstractions GT

uses open coding, since open coding represents the initial coding of a research project (Strauss, 2003).

However, Strauss and Corbin (1998), claim that in order to uncover names and develop categories, the thoughts, ideas, and meanings in the texts being analysed need to be exposed. They emphasis that this first analytic step when analysing a text is of utmost importance for the rest of the analysis. Furthermore, Strauss and Corbin (1998) break down the text into isolated parts, which are examined and compared for similarities. During this process, they group together events, happenings, objects, and actions/interactions that are conceptually similar in nature or related in meaning. This lead to "new and more abstract concepts termed categories" (Strauss and Corbin, 1998: 102).

To describe what happens in the field the researcher engages in a process to construct a web of names, it is a technique of conceptualizing and labelling. However, the labelling of concepts needs to reflect the context they are part of.

> "Contrary to what many persons thinks, conceptualizing is an art and involves some creativity, but it is an art that can be learned. Because our purpose is to illustrate the act of naming and not how we actually analyze data… Not every possible phrase or idea is conceptualizes. In addition, the names that we use are arbitrary other researchers might use other label, depending on their foci, training and interpretation. Also note – and this is very important – that the conceptual name or label used should be suggested by the context in which an event is located. By "context", we mean the conditional background or situation in which the event is embedded" (Strauss and Corbin, 1998: 106)."

According to Strauss and Corbin (1998), the purpose of labelling or giving names to categories is to be able to classify an event, happening or object, and the corresponding implicit or explicit action concerning that object.

There are two ways of doing labelling, either by using the imagery or meaning the analyst places on the objects related to the context in which they appear, or by using the names the respondents' use (Glaser and Strauss, 1999). When the analyst makes direct use of the respondents' words, these expressions are called, in vivo codes. When the analyst uses his own words to describe the meaning of an object, these expressions are called, in vitro codes (Glaser and Strauss, 1999).

According to Strauss and Corbin (1998), to be able to connect the names arrived at when labelling the data, the researcher looks for structure and processes in the data set. Structures are discovered in the data by answering why events occur. Processes are discovered by finding answers to how persons interact/act.

Strauss and Corbin (1998) emphasis that a researcher using GT shall answer the questions how, why, where, when, who, and with what consequences. This will make the analyst able to relate structure to process during the coding process. Linking structure and process will help the analyst to understand the circumstances in which problems, issues, happenings, or events pertaining to phenomenon, are situated or arise.

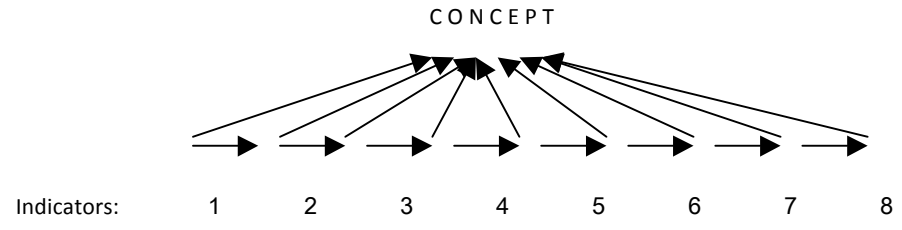
> "Process, on the other hand, denotes the action/interaction over time of persons, organizations, and communities in response to certain problems and issues. Combining structure with process helps the analyst to get at some of the complexity that is so much part of life. Process and structure are inextricably linked, and unless one understands the nature of their relationship (both to each other and to the phenomenon in question), it is difficult to truly grasp what is going on. If one studies structure only, the one learns why but not, how certain events occur. If one studies process only, the one learns how but now why certain events occur" (Strauss and Corbin, 1998:127).

For Strauss and Corbin (1998) it is important to study both structure and process to capture the dynamics and evolving nature of events.

Furthermore, using GT emphasises the importance of developing theory by grounding the theoretical abstractions in the data. Grounding ensures that the theory produced is based on a systematic and extensive data collection and coding. GT is not only a way of organizing and collecting mass of data, but to organize the many ideas that emerge from the data (Strauss, 2003). Another feature distinguishing GT from other qualitative research models, is the repeated "combination and permutation done at each operation (theoretical sampling, comparative analysis, theoretical saturation, memos, sorting and so forth). These operations are essential to the development of densely woven and tightly integrated theory" (Strauss, 2003: 24-25).

In order to develop categories, it is necessary to conceptualize the facts in the collected data. In GT, this is achieved by using a "concept-indicator model" (Strauss, 2003: 5). In a concept-indicator model, events or actions in the data are compared, coded into indicator, of events or actions, and further extracted into categories, or concepts, representing the collective indicators.

Figure 6: Concept-indicator model adapted from Strauss (2003: 25)



According to Strauss (2003), to indentify the facts represented by the indicators. In the studied data, it is necessary to identify the following four elements in the data:

1. Conditions
2. Interaction among the actors
3. Tactics and strategies
4. Consequences (Strauss, 2003: 27-28).

To find each of these elements the researcher needs to be observant, and look for particular cues in the data. Typically, by looking for words like "because", "as", "on account of", or "since", the researcher can discover conditions. Consequences may typically have cues such as "because of that", "the result was", "the consequence was", or "in consequence". Interactions among actors are those actions that are not straightforward from tactics or strategies. According to Strauss, using the coding paradigm is necessary for coding to be coding (Strauss, 2003: 27-28). Doing GT properly means to follow these four steps in the data analysis, and gives the researcher an analytical tool for generating theory.

This demonstrates that GT has a distinct way of working with the collected data using a set of prescribed procedures. Practicing GT involves going back and forth between data analysis and data collection. During the data analysis new categories are developed. Subsequently, the categories are tested on the collected data, in order to confirm, disconfirm, or modify them (Strauss, 2003; Strauss and Corbin, 1998). By testing the categories on the data, the categories are grounded in the data.

GT operates almost in a reverse fashion compared to research that is more traditional. Rather than beginning the research with developing hypothesis, the first step in GT is data collection. Data collection can be done using a variety of methods, such as observation, questionnaires, and interviews. Parallel with data collection, a variety of methods can be used to analyse the data such as open coding, axial coding, selective coding, and the concept-indicator model (Strauss, 2003). The end-result of doing GT, are conceptualized categories that are the basis for creating a theory, or a reverse engineering hypothesis. Often the application of GT defines a central characteristic of the collected data, which become the core category. This approach is in contrast to the traditional model of research, where the researcher chooses a theoretical framework and applies it to the studied phenomenon (Allan, 2003).

According to Strauss and Corbin (1998) the process towards generating theory from the collected data starts with asking questions to the data and making theoretical comparisons. To help the researcher during this process Strauss and Corbin (1998)

suggest first a set of analytical tools to "increase the sensitivity, help the user recognize bias to some degree, and help him or her overcome analytical blocks" (p. 87-88). The analytical tools according to Strauss and Corbin (1998) are the use of questioning, analysis of words, phrases, or sentences, and further analysis through comparisons. The data analysis continues with open coding, axial coding, and selective coding as advocated by Strauss and Corbin (1998) in their GT method.

From the collected data, key points are marked with a series of codes extracted from the text. Then these codes are grouped into concepts to make them workable, and from the concepts core categories are formed, which is the basis for the theory.

The end-result of GT is to develop conceptualized categories. According to Blumer (1998), these developed categories and their relationships, are vital parts of the arguments and discussions in the communication among investigators, and necessary to enhance the development of science (p. 153-182).

5.5 Some Challenges in Central Grounded Theory Approaches

How to process or analyse data will depend on what GT method the researcher wants to use. GT has developed in many directions since Glaser and Strauss first published their work back in 1967.

However, according to Allen (2010) the following four GT approaches have made considerable contribution to GT, by being innovative and original. Glaser and Strauss developed the original GT approach in 1967. Strauss and Corbin (1998) developed a later version of GT. Charmaz (2006) developed the social constructivist approach to GT. Clarke (2005) developed a more post modernistic version of GT. All of these four approaches to GT have in common that they provide strong arguments for the usage of GT. However, they have proven weak on supplying examples of how a researcher should apply GT in practice (Allen, 2010).

Glaser and Strauss' (1999) version of GT commonly use the word "emerge" to illustrate that data should not be forced into categories from any pre-existing theory, but should emerge naturally from the empirical data (Allen, 2010). However, a critique of Glaser and Strauss version of GT is, according to Allen (2010), that Glaser and Strauss do not provide enough good examples of how to generate theory. Nevertheless, Glaser and Strauss emphasis that new researchers should publish their own method books of how to apply GT, and as such their book have functioned as an inspiration to many researchers (Ibid.).

Strauss and Corbin's' (1998) version of GT have many useful examples of how to apply GT to a context and demonstrate what steps the researcher needs to follow during the research process (Allen, 2010). Nevertheless, this book is no procedural manual for

doing GT, but offers a way of linking conditions, consequences, and process in a systematic way (Ibid.). A critique towards Strauss and Corbin (1998) is their suggestion that the researcher can use experiences as well as literature to generate concepts (Allen, 2010). This raises the challenge between forcing and emerging categories. Strauss and Corbin (1998) state that, "theorizing is the act of constructing" (p. 25). Therefore, according to Allen (2010), using Strauss and Corbin version of GT leads to theories being constructed, through conceptualization, from data, rather than being discovered in the data.

Charmaz (2006) version of GT takes the idea of theory as a construction further in her interpretative approach to GT (Allen, 2010). Charmaz (2006) version of GT is an "interpretive portrayal of the studied world, not an exact picture of it" (p. 10). According to Charmaz (2006), researchers are not separate from their theories but construct them through their interactions with people, places, and research perspectives (Allen, 2010). What differentiates Charmaz (2006) version of GT from those already mentioned, are the assumption that neither data nor theories are discovered, but are constructed by the researcher and the research participants. Therefore, according to Charmaz (2006), answers to interview questions are "a construction-reconstruction-of reality" (p. 27). Charmaz (2006) points out that the act of theorizing means constructing abstract understandings about the world. Theory neither emerges nor is discovered, but is instead constructed. According to, Allen (2010), a critique of Charmaz (2006) version of GT is that researchers might be tempted to use her approach as a recipe to follow rather than suggestions. Furthermore, Charmaz (2006) talks about some common misunderstanding of using GT, however she is unable to identify what they are and how to correct them (Allen, 2010).

Clarke's 2005-version of GT emphasises situations as the locus of inquiry rather than actions or processes (Allen, 2010). Clarke (2005) wants to "regenerate the grounded theory method towards new approaches" (p. 37). She uses situational maps in her application of GT. A critique of Clarke's approach is that categories do not totally emerge from the data when using her technique, but are constructed (Allen, 2010). Furthermore, according to Allen (Ibid.), Clarke makes assumptions regarding social justices, and emphasis that the researcher must pursue in the data descriptions that emphasis social justice. She pursues this goal frequently referring to Foucault's idea of power and how these institutional systems hold power over the players such that the respondents are "forced to deal with them" (Clarke, 2005: 87). Clarke concludes that these non-human elements will have an effect on the human actors. A critique of Clarke's approach to GT is that "she has a tendency to be overly simple in her summation of the deficits contained within the traditional approach" (Allen, 2010: 1617). Furthermore, Clarke states that traditional GT is linear in nature, but both Glaser and

Strauss explain frequently in their book from 1967 that the process of GT is circular where the analyst needs to return back and forth from coding, memoing, and hypothesizing (Allen, 2010).

All of these central approaches within GT can provide a researcher with a broad set of tools and explanations in order to understand and use GT (Allen, 2010). "GT coding is a form of content analysis to find and conceptualise the underlying issues amongst the noise of the data" (Allan, 2003: 1).

Additional noise, relating to the analysis of the data, is that the researcher can have too many preconceived opinions about the studied field before his or hers investigation. Such opinions can come from studying literature before going into the field. Even if Glaser and Strauss (1999) emphasis, in their version of GT, that they want to avoid applying theories to a field by a researcher, they do recommend literature research before fieldwork (Allan, 2003). Glaser and Strauss (1999) encourage researchers to "use any material bearing in the area" (p. 169). Therefore, Glaser and Strauss' (1999) version of GT do not advocate going into a field without being prepared.

As shown so far, there are many ways to apply GT. My approach to GT is based on Glaser and Strauss (1999) version, and on Strauss (2003) version, in the coding process.

5.6 Producing Categories from the Data

The process where the categories are produced from the data is called coding, and the descriptor phrase used is called code (Allan, 2003).

In order to find patterns in the data, my coding process starts with key point coding. Key-point coding is done to ensure a better encapsulation of the opinions that appear in the interview text, in relation to their relevance for research question(s) to be answered (Allan, 2003). With key-point coding, the focus in the coding process is on identifying the key-points in the interview text.

As the coding process proceeds, the key points become denser, and codes are produced (Allen, 2003). The coding process continues with the aggregation of concepts, and when the final concepts are compared to each other, then the categories emerge. Glaser and Strauss (1999) see the coding process as completed when a final category emerges.

Axial coding is the process from open coding to a higher level of abstraction necessary to define categories. During axial coding, the researcher develops a category by specifying the conditions behind the category, the context for the category, and the action/interactional strategies defining how the category is handled, managed, and carried out (Goulding, 2002: 78). Since GT rests on developing core categories, it is necessary to discuss what a category is.

According to the Stanford online Encyclopaedia of Philosophy categories can be seen as an inventory list of what there is in a studied area:

> "A system of categories is a complete list of highest kinds or genera. Traditionally, following Aristotle, these have been thought of as highest genera of entities (in the widest sense of the term), so that a system of categories undertaken in this realist spirit would ideally provide an inventory of everything there is, thus answering the most basic of metaphysical questions: "What is there?" (Thomessen, 2009).

According to Thomessen (2009), there are various diverging ways to define categories, but all categories are constructions of our thoughts. However, a fallacy of constructing concepts from thoughts is that the categories are separated from reality itself (Ibid.). Hence, this has led to an approach where the categories need to be clarified in relation to our conceptual system (Ibid.). Kant (1798/1958) made a shift in the conceptualist approach by drawing out those, priori categories that are necessary for any possible cognition of objects, because he saw these categories as applicable to any object of cognition and they have a kind of ontological importance in respect to a studied phenomenon (Ibid.)

5.7 Developing a Grounded Theory Inspired Approach

Glaser and Strauss (1999) in their development of the GT approach, encourage researchers to seek for new approaches for doing GT. This is an encouragement, I want to follow.

My aim is to focus on knowledge generating processes, and to make a consistent representation of the findings by avoiding "the building block world view" (Addleson, 2001: 177). According to Addleson (2001), a "building block world view is defined as a world where tasks and goals are concrete, discrete, easily identified and are capable of being enumerated and ordered and a world where tasks exist independently of what people think or believe" (Addleson, 2001: 177).

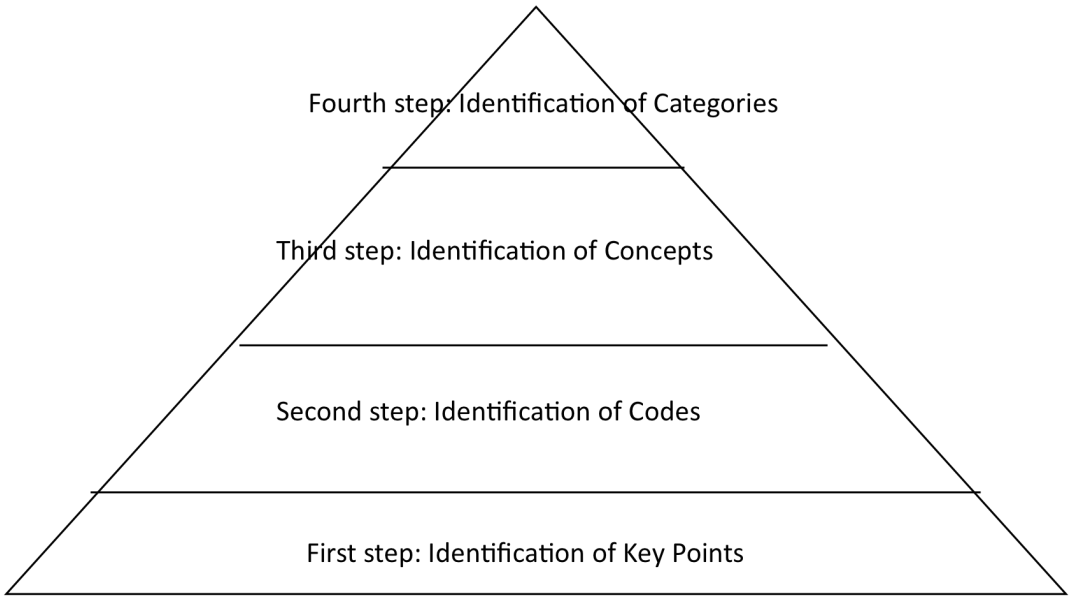
A building block view on product development will fail to recognize the process perspective and make the learning process subordinate. A more holistic understanding of product development views practice, and learning as inseparable. The emphasis is placed on human mechanisms such as collaborations, discussions, emotions, preconceptions, and authority continuously supervised by adopted models, routines, and procedures.

Furthermore, GT is a bottom-up approach within the symbolic interactionism research tradition (Glaser, 1994). GT emphasises longitudinal studies, where the

researcher investigates and reinvestigates the studied object (Glaser & Strauss, 1999; Strauss and Corbin, 1997). In addition, during the investigation of the empirical data, the researcher reconsider his/hers understanding of the object after each investigation, because the time, the focus and the questions posed may change. Consequently, each visit to study an object, may enhance the researchers understanding of it. The purpose of such an approach is to arrive at a deeper understanding of the area of investigation.

Moreover, in order to arrive at the categories, the original interviews have gone through four main steps in hierarchical order as illustrated in figure 7 below. At each step, a naming and labelling procedure moves the theorization process upwards in the pyramid.

Figure 7: Illustrating the four steps in my Grounded Theory Inspired Approach



The steps applied in my model are interlinked. The final categories at the top of the pyramid yield hypothesis for a theory of investigated research question.

The first step in the pyramid, are the key points. The key points represent the lowest level in the hierarchy of a GT inspired approach. Key points aid the researcher in avoiding a mass-accumulation of data, when analysing the data word-by-word and line-by-line. Moreover, key-points represent a condensation of the central meaning from the interviewees' utterances. The use of key points help to shorten the data by translating each answer given by the respondents and by focusing on the main opinion given in each of the respondents' answers. The research question guides the development of key points.

The second step in the pyramid, are the codes. The codes are aggregated from the key-points, to ensure a further refinement of the selected words or phrases. For a trained

GT researcher, the identification of common codes starts at the first interview, at the first observation, or by reading the first texts, but for a novice, the process towards identification of the codes and concepts is slower.

The third step, are the concepts. The concepts use the codes and further refine them into less wordily phrases.

The fourth step, are the categories. The categories use the concepts and refine them into sub-categories and a central category, preferably as single words.

In this way the process towards the final category, or categories, moves upwards from long and wordily descriptions, to narrow and condense descriptions.

5.8 Applying a Grounded Theory Inspired Approach

As shown, in this chapter, the fundament of GT rests on developing theory from empirical data through a prescribed sequence of steps. In my thesis, I have used the concept-indicator template advocated by Strauss (2003: 27-28) to identify the central concepts in the empirical data.

My Grounded Theory Inspired Approach (GTIA) uses conceptualization and aggregation to analyse the data (for a complete analysis look at Appendix IX). In addition, the GTIA approach uses open coding and analyse the interviews line-by-line, and looks for codes in each sentence. This process produces a large amount of key points with potential meaning and relevance.

The first step is to produce key points, and key point coding is the first link to the research topic (see table 9). Table 9 shows how the interview text translates into key points, with I2 standing for the interviewer and S1 standing for the respondent.

The second step is to compare the key-points and group them into codes. Codes represent the building blocks of theory grounded that will emerge from the data. This process happens by going from open to axial coding, by first making a description of what took place during product development by sorting interviewees' statements into themes. These themes function as labels to help finding codes.

The third step is to use dimensional analysis on the codes. A dimensional analysis defines a dimension as an abstract code with associated properties, and where the properties describe the dimension. For example, the studied company defines innovation along the dimensions of technology driven projects versus economically driven projects, depending on the degree of technology supply to the projects. Technology projects supply technology to a broad spectrum of products, while economically driven projects are strategic and more market oriented. The output provided by technology projects will provide a spin-off to other projects.

This process from interview text to key points to codes is illustrated in table 8, where the procedure for each step in my GTIA approach is described in detail.

Table 8: Excerpt from the translation of the Interview Text to Key Points

Interview Text	**Key Points**
I2: Hvordan opfatter I en produktudvikling? Hvad er produktudvikling for jer? og hvordan håndterer I det?	What is product development for you? How do you deal with it?
S1: Det er jo sådan, at man kan sige, at for vores vedkommende mht produktudviklinger der kører vi jo nogle projekter hele tiden som forstået rigtigt gerne skulle bringe os fremad. Forstået på den måde at det svære er nyudviklinger og bringe os endnu mere frem teknisk. Selvfølgelig baseret på, hvad er markedsbehovet. Det er jo den ene side af det at udvikle. Arbejde med nye produkter. Men den anden side af det, det er at man kan sige, hvordan skal jeg udtrykke det, at ældre produkter bringes op til, du kan sige, the state-of-the-art. Fordi de er stadigvæk salgbare. De skal måske have et teknisk løft eller et andet løft. Det er så en anden proces der kører. Man kan godt sige, at det er de to hovedgrene, der kører. For det løbende er noget. Ja det må vi nok sige. Det er den måde, som vi deler to kategorier. Lad os prøve at holde fast på sådan to hovedkategorier. Der er flere projekter inden for dem. Der er underprojekter, således at vi måske typisk har, afhængig af hvor stor. Man kan godt sige, at vi har 5-10 projekter der kører hele tiden. Nogle af dem er tunge. Kører over flere år. Andre kører måske kun over nogle få måneder, for så er de løftet op til det som markedet efterspørger. Og som vi mener, at maskinerne skal se ud. Nu ved jeg ikke, om det er vigtigt at fastslå her, at vi arbejder som sagt inden for svejsning og vi udvikler kun, og vi arbejder kun inden for svejsning.	Run projects that should bring us forward. New developments to bring us more forward on a technical basis, based on market need. Old products brought up to state-of-the-art and still sellable. Old products receiving a technical lift or other type of lift. Heavy projects that run over several years. Projects running only a few months lifted to market standards. Work within the welding industry.
S1: Ja den er så bred. Her inden for svejsebranchen. Dér har vi så valgt nogle segmenter ud, som vi arbejder inden for. I princippet sige, at vores hovedsegment, som udgør 80-90 % af vores udvikling. Det er lysbuesvejsning. Det er altså et segment af svejseområdet. Så også dér har vi altså ligesom specialiseret os.	Working within selected elements of the welding industry. Eighty to ninety percent of our development is within the electric-arc welding segment.
I1: I forhold til kunden?	In relation to customers?
S1: Ja det er det. Vi går efter et bestemt branchesegment. Man kan så sige inden for svejsning er det det mest anvendte område. Hvor det største marked er også. Man kan sige på verdensplan også her i landet. Kunder meget stor spredning hovedsegmenter delt op i massevis af grupper det har meget at gøre med, er det sværindustri eller er det finindustri, finmekanik. Hele det spekter derimellem bruger man lysbuesvejsning. Hvor sværindustrien typisk er offshore konstruktion, skibsbygning, Storebæltsbroene og der skal svejses lidt sammen hist og pist.	We aim for a specific industry segment with the largest market – from large industry to precision mechanics – within the entirety of this spectrum, electric arc welding is used.
S1: der i (print) findes der nogle komponenter. Også nogle småsvejsninger xx medicinalindustrien, medikoteknik, hvor de laver meget fine instrumenter. Dér leverer vi også svejsemaskiner til. Så det er et stort spekter. Så findes der jo derimellem alle, ja man kan sige alle typer af virksomheder alle virksomheder der arbejder med sammenføjninger af metaller bruger lysbuesvejsning i langt de fleste tilfælde. Og dér deler vi jo op i, jeg ved ikke hvor langt vi skal ned i det, I må spørge, og sige stop.	Some components within the medical industry where we deliver our welding machines make very fine instruments. Then there are all the companies that work with joining metal that use electric arc welding.

I2: Lige til at sige stop, hvis vi kan gå tilbage til produktudvikling. Med meget stor spredning på kunderne enten bredt alle sammen eller også specialiserer du dig	Product development. Large spread of customers is either broad or you specialize

The interview text is on the left-hand column in table 9, and the key-points are on the right-hand column.

The common denominators repeatedly found as key points in table 9, have a bearing on the research questions. Firstly, as either something to "bring us forward", which is defined in the interview text as gaining more technical knowledge. To update existing products the company uses technical knowledge, which brings "products up to the-state-of-the-art", or gives products a "technical lift". Secondly, the respondent emphasizes the importance of market orientating the product development process by using phrases such as "sellable" and "based on market need". Thirdly, the respondent's answers demonstrate how factors such as defining the market segments for the company's products helps to decide whether the company wants to be a specialized or a broad supplier.

Three important elements in table 9 influence employees' understanding of product development. The first element identifies why the company starts new product development projects. The second element identifies the importance of considering market influences on product development projects. The third element demonstrates how strategic decisions influence what market segment the company aims for, and whether the company wants to be a broad or a specialized supplier.

These three elements become a grounded representation of the employees' understanding of product development by evaluating them against the remaining interviews.

Table 9 demonstrates the empirical data analysis from key points to codes. The left hand column in table 9, Id, identifies the interview where the key points emerge.

Table 9: Excerpt from translation of key points to codes

Id	**Key Points**	**Codes**
B1pr4	Run projects that should bring us forward. New developments to bring us more forward on a technical basis, based on market need. Old products brought up to state-of-the-art and still sellable Old products receiving a technical lift or other type of lift. Heavy projects that run over several years. Projects running only a few months lifted to market standards. Work within the welding industry.	Forward projects New developments Forward on a technical basis Market need State-of-the-art product Technical lift Heavy projects Short projects lifted to market standard

B1pr5	Working within selected elements of the welding industry. Eighty to ninety percent of our development is within the electric-arc welding segment.	Defining welding segments Electric-arc welding main segment
B1pr6	We aim for a specific industry segment with the largest market – from large industry to precision mechanics – within the entirety of this spectrum, electric arc welding is used.	Defining market segment
B1pr7	Some components within the medical industry where we deliver welding machines make very fine instruments. Then there are all the companies that work with joining metal that use electric arc welding.	Defining market segment
B1pr8	Product development Large spread of customers is either broad or you specialize	Broad or specialized supplier

In table 9, the right-hand-column shows the codes derived from the key points. The codes represent "higher order commonalities" when they are grouped together (Allan, 2003: 3). The questions posed during the interview are removed, since the aim is to arrive at higher order commonality codes based on the respondents' answers. According to the codes, new development projects give the company a technical lift and bring their existing products up to the-state-of-the-art level. Table 9 shows how the product development process is orientated according to the company's relevant industrial segment and decides whether the company is a broad or a specialized supplier. Subsequently, because of the accumulative process in the second step towards a GTIA, three codes emerge. The first code emphasizes what factors influence the content and the results of the product development process. The second code emphasizes a stronger market orientation of the development process, and the remaining codes in table 9 demonstrate how strategic decisions shape the company.

The third step is to develop the concepts. In order to develop the concepts, the codes are further refined into less wordily phrases. This is illustrated in table 10. In table 10, the left-hand column represents the identifier as before, the middle column represents the codes and the right-hand column represents the concepts.

Table 10: Excerpt from translation of codes to concepts

Id	Codes	Concepts
B1pr4	Forward projects New developments Forward technically Market needs State-of-the-art product Technical lift Heavy projects Projects lifted to market standard	Forwarding projects either through new developments, new techniques, and market needs, lift product to state-of-the-art or to market standard.
B1pr5	Selected industry segment Electric-arc welding	Choice of industry segment, electric-arc welding, largest market or medical industry
B1pr6	Largest market Precision mechanics	
B1pr7	Medical industry Fine instrument welding	
B1pr8	Spread of customers Specialize	Spread of customers or specialize

The right-hand column in table 10 demonstrates how the codes in the middle column orientate the product development process according to the knowledge generation in the development projects, which results from a stronger market focus, and strategic focus.

The fourth and final step is the translation of concepts into categories. The categories reflect the highest level of aggregated theoretical descriptions, and they represent the last building blocks towards a theory. In table 11, the concepts are developed into the categories that will represent the final elements used to build a theory for the studied domain.

Table 11: Excerpt from translation of categories to categories

Id	Concepts	Categories
B1pr4	Forwarding projects either through new developments, new techniques, market needs, lift product to state-of-the-art or to market standard.	Project emergence
B1pr5 B1pr6 B1pr7	Choice of industry segment, electric-arc welding, largest market or medical industry	Strategic considerations
B1pr8	Spread of customers or specialize	

All of the nine interviews representing the empirical data in this thesis are processed in the same way as Tables 8, 9, 10, and 11 demonstrate. In total, the GTIA development process accumulates the data through four steps. These four steps interconnect and move the process towards higher order commonalities at each step. Processing the data through the four steps, from key points, to codes, to concepts, and finally the categories, enable hypothesis to be formulated. Eventually, a final core category links together all the other categories, and defines them as sub-categories.

5.9 Language Aspects

The analysed data were collected in a language not being my native language, interpreted in my native language, and then presented in a third language. This mix of languages consists of reading and transcribing in Danish, interpreting in Norwegian, and writing in English.

A language reflects the historical socio-cultural conditions of its origin, which give words an extended meaning. For a non-native speaker, the hidden meaning lying in the use of particular words can be difficult to identify. The danger of working with several languages is the disappearance of subtle meanings from the interpretation, assigning new understandings to categories, or worse, an opposing meaning.

When doing a translation it is difficult to know the best fit between the original meaning and the translation of the meaning. Caution need to be advocated with respect

to what meaning we assign to the data. Within these constrictions, I have tried to be as accurate and coherent as possible in my interpretation of the data.

5.10 Considerations when doing Grounded Theory within Product Development

In Grounded Theory (GT), the responsibility for verification of a study rests with the researcher (Creswell, 1998).

> "verification in grounded theory research is an active part of the process of research and becomes part of the standards one should use to judge the quality of the study"(Creswell, 1998: 208-209).

Strauss and Corbin (1990) pose the question under what conditions does the theory fit with reality, give understanding, and be useful (practically and theoretically)? Creswell (1998) claims that this question emphasis the importance of fit, understanding, and utility. Furthermore, that the verification process lies in the different stages when conducting GT research (Ibid.). Verification is a result of processing the data through open coding and interrelating the coding steps towards the final categories (Ibid.).

> "The researcher poses questions that relate the categories and then returns to the data and looks for evidence, incidents, and events that support or refute the questions, thereby verifying the data. This procedure is called discriminant sampling. Then after the researcher writes the theory, the literature is use for "supplemental validation"; the researcher references the literature to give validation for the accuracy of the findings or how the findings differ from published literature." (Creswell, 1998: 209).

The perspective of the researcher will colour the outcome of their research. Researching product development by focusing on risks is one way of understanding the process. A different viewpoint is to emphasize how the process shapes behaviour. The latter viewpoint can identify how the distribution of skills and knowledge is within a company.

Furthermore, understanding product development processes depends on the context where they take place, what type of people are involved (their background, social class, position in the company and how they are perceived by their environment) (Webb et. al., 2002). The argument for the latter is that,

"to reason, is connected to the position from which the social agent acts. Thus, there is no difference between, working out the move to score goal, as it is to work with a philosophical proposition from Wittgenstein. They simply occur in different contexts and have their own demands" (Webb et al., 2002: 140).

Any qualitative or quantitative research will be coloured by the focus the researcher chooses. Therefore, what to measure, by whom, under what circumstances, and by what methods, will influence the findings. Furthermore, research is context-dependent, and context-dependency reduces the possibility of transferring the research results to other similar cases. However, with qualitative research there is no need to strive for absolute generality, because the purpose is to demonstrate what takes place within a particular context, and learn from that.

Nevertheless, we should not call such studies in-depth studies, because a researcher will never be able to go in-depth. All studies relying in any way on individuals will depend on the individuals' willingness to go deep, which is something the researcher is unable to control. Rather than using generality as a measurement of qualitative research, such research should be valued based on its authenticity and validity. Data consistency determines how well the data will answer the chosen research question.

In order to fulfil the requirements to authenticity and validity, various actors in the company was interviewed about their view on product development. In this way, we were able to obtain multiple viewpoints on product development, and these different viewpoints create a certain objective distance to the data.

A good study of a single example can offer enough insight and enrichment to expand our understanding of the field under study (Flyvebjerg, 1999). A qualitative study offers the possibility to study something in detail, and gives an opportunity to produce a richer picture of the studied area than a quantitative study provides.

To accept something as a fact, there needs to be a pre-established agreement on the model that produced the fact. Within social sciences, such a pre-established agreement is difficult to find since a central part of the fundament of social science are questions such as: What is a fact? When is something a fact? Can we claim for sure, that something is a fact about the world (Huges and Sharrock, 1997)? Nevertheless, my thesis aims to establish some categories useful for describing employees' experiences, and behaviour, and knowledge needed to conduct product development.

According to Hart (1998), the design features, and intended outcome of research, help to classify the research. He claims that reading a piece of research involves an effort to understand why the research was done in a particular way, and what its intended outcome were meant to be. "A bulk of research in the social sciences is aimed at

explaining, exploring or describing the occurrence or (non-occurrence) of some phenomenon" (Hart, 1998: 44). Therefore, Hart (Ibid.) shows that it is important to understand the purpose of the research, since the goal of the research will decide how to design, present, and understand the research.

Whether product development research originates from an economic, human relation or management tradition, one finds that much of the research focuses on what factors influence the success of product development (Brown and Eisenhardt, 1995; Cooper, 1991). Hence, rather than having focus on success factors, I want to know how employees perceive product development, and how a systemic approach to product development influences employees' participation, and knowledge attainment. The empirical findings allow extraction of a multitude of perspectives on product development.

Using employees' experiences to focus on product development represents a bottom-up perspective. A bottom-up approach emphasises how to give voice to a broad spectrum of product development participants, and not only managers. Interviewing a broad spectrum of participants in product development provide many different views on how people are comprehending the innovation process.

Nevertheless, caution need to be advocated when studying social learning processes, because a social learning process will always be at the expense of something or someone. Therefore, interviewing a broad spectrum of participants opens up the possibilities for seeing how peoples' interests influence their social interaction. However, one should bear in mind that people are under the influence of powers and decisions taken by others. Thus, a particular interpretation of information will suit some peoples' interest while harming others (Easterby-Smith et al., 1999).

A more critical approach to learning can be found in Hudson (1999). He argues that:

> "Recognizing the importance of innovation and knowledge creation to economic success is hardly novel and that the contemporary focus on learning is in many ways simply a new twist on an old theme that "knowledge is power"'(Hudson, 1999: 59).

In the studied company, there is a continuous need to harvest knowledge in order to support the innovation process. Only by being best at knowledge harvesting will the company have an advantage compared to their competitors. Accordingly, knowledge is not only power, but also a question of being able to harness the knowledge in a way that can provide possibilities for economic success.

6. Developing the Categories from the Data

This chapter presents the results of the data analysis, using a Grounded Theory Inspired Approach (GTIA). The four steps in the data analysis process is shown in detail for one interview. At the end of this chapter, the final categories emerge. Appendix IX contains the complete analysis of all the interviews in my thesis.

6.1 From Interview text to Key Points for the First Interview

The coding process using a GTIA approach starts by generating key points from the raw interview data. Table 13 shows the analysis of the first interview in full. The left column, in table 13, consists of the id (identifier), which identifying the interview. The first number in the identifier (Id) classifies what number of interview this is. The first interview will be number one, and the second interview has number 2 and so on. The next part of the id, identifies the respondent. The last part of the id, is the line number in the interview text.

The interview text, is first summarized into key points, and then the key points are grouped together. The key points are the words and sentences the interviewees' use. The key points represent higher level of abstraction and are analytical, since the informants interpret not simply describe. Grouping the key points together gives "higher order commonalities" (Allan, 2003: 3).

The first two key points "not a large company reasonable control on everything", and "delegate responsibility for project parts", capture how control is easier to achieve in a small company and how project control improves when delegating responsibility for project parts.

The next key point, "run projects to bring the company forward either, technically through new developments, bring products up to the state-of-the –art, give old products a technical lift, heavy projects run over several years, short projects to lift products to market standard", describes what considerations lie behind starting up development projects. Furthermore, the company needs to identify, and consider their biggest market "electric-arc welding constitutes 80-90% of development".

Table 12: Table showing the coding from interview text to key points for the first interview

Id	Interview text	Key Points
B1pr2	We are not a large company and have reasonably control on everything. Work delegated and someone given responsibility for de different parts.	Not a large company reasonable control on everything Delegate responsibility for project parts
B1pr4	Run projects that should bring us forward. New developments to bring us more forward technically based on market need. Old products brought up to the state-of-the-art and still saleable. Old products having a technical lift or another lift. Heavy projects run over several years. Projects running only a few months to lift to marked standards. Work within the welding industry	Run projects to bring the company forward either, technically through new developments, bring products up to the state-of-the –art, give old products a technical lift, heavy projects run over several years, short projects to lift products to market standard
B1pr5	Working within selected elements within the welding industry. 80-90% of our development is within the electric-arc welding segment	Electric arc welding constitutes 80-90% of their development.
B1pr6	Aim for a specific industry segment with the largest market – from large industry to precision mechanics – within the whole of this spectrum electric-arc welding is used.	Aim for the industry segment with the largest market
B1pr7	Some components within the medical industry that make very fine instruments where we deliver welding machines. Then there are all companies that work with joining metal use electric-arc welding	
B1pr8	Product development. Large spread of customers either broad or you specialize	Choose either a broad spread of customers or become a specialist supplier
B1pr11	Projects get a number and a name. Projects followed up once a month in the product committee meetings. Feedback and status on projects. Run according to integrated product development with five phases. Approval of phase shifts. Describe what should be investigated tested approved before a phase shift can be done.	Controlling projects through registration, formal follow up meetings giving feedback, use of a product development model, approval decisions based on pre-investigations.
B1pr12	Participate in product committee meeting, management group approves phase shifts, but just as a follow up. Management group consists of all department managers. Sales, marketing and development department heavily involved in the phases. Marketing investigations covers economical calculations, lifetime, expected sales, and expected costs. In product committee meetings, where managers participate all departments involved automatically part of the product committee.	Product committee meeting where management participates. Approve phase shifts. Sales, marketing and development heavy involved. Marketing investigation covers calculations of lifetime, expected sales, and costs.
B1pr13	Start up a co-play of many things. Difficult to answer how a project started. Information from seller, service, and customers. Listens to them. Create a picture. Investigate ourselves (development department). Technological development. Keep eyes and ears open to what happens in the welding industry. What demands the customer makes.	Project start up a co-play of many things. Listen to information from sellers, service, and customers. Make a picture. Investigate. Technological development. Alert to happenings in the industry. Customer demands
B1pr14	The company started by focusing purposeful on a market segment that needed a particular type of welding machines. Focused on the car repair industry and welding of rusty bodywork. It was the mechanism of electric arc welding that triggered the development projects. After a while a complete program for this type of industry. Looks at the trend within the industry and discover something that the customer need. It is a co-play with the industry that triggers projects.	Focusing purposeful on a market segment needing particular welding car-repair and welding rusty bodywork triggered electric-arc welding development. Look at trends in the industry to discover customer needs.
B1pr15	Listen much to customers and what language they have. Evaluate if this really is a market for us. Focus on large consumption market. Avoid fulfilling customers wish when there is a limited customer group. Talk to customers - What would you pay for something that could do this and this? In development phase, perform testing at customer/potential customer. In the release phase customers are asked	Customers" language. Evaluate what is a market for us focus on large consumption market. Avoid limited customer groups. Talk to customers what would you pay for something like this. Testing at customer site in the development phase and ask customers in the release phase.
B1pr16	Talked to customers in many of the product development phases. Design wise. User friendliness	Customer involved in many product development phases, both design wise and related to user friendliness.
B1pr17	Build machines of standard components and elements to reduce purpose-built. Machine design and operation panels are easily purpose-built to our machines. Better than competitors to use standard elements smart and rationally.	Build machines using standard elements to reduce purpose-built. Operation panels easily purpose-built. Better than competitors to use standard elements in a smart and rational way.

B1pr18	Produce large numbers. A welding machine, not a mass product, but a batch product.	A welding machines not a mass product, but a batch product.
B1pr19	Sell around 1000 of our largest machine pro anno.	Largest machine sold around 1000 pr. anno.
B1pr20	We are not restricted to our ability to produce.	Ability to produce is no restriction
B1p21	Runs linear production.	Production runs linear.
B1pr22	Sales department are included all the way	Sale included in the product development process all the way
B1pr23	There are some delivery phases. All functions participate the whole time	All functions participate in the development process all the time.
B1pr24	Sales department comes with ideas for projects, but this includes economy. Marketing included discussing design, instruction manuals and spare parts lists, brochures. Participate the whole time, but with variance in intensity. Appointment of project manager early. Project manager runs the project the whole way through.	Sales present ideas for project but also the economy in them. Marketing included discussing design, manuals, spare part lists, and brochures. Participation by other departments varies in intensity. Project manager appointed early and runs the project until completion.
B1pr25	Not difficult to get good specialists. Difficult to get a project manager that can run the whole thing through. Have competent marketing personnel, sales personnel, development personnel, technical development personnel, production personnel, but those who really has the overview that is the problem	Difficult to get a project manager that can run a project until completions and have overview of the product development process. Specialist can be found but competent projects managers less easy to find.
B1pr26	A technician, an engineer, electronics engineer, el-engineer. To be a project manager should be part of one. Incredible much to do with experience. What one learned to keep such a process going	Being a project manager should be part of one and it depending on experience and what one has learned to keep a product development process going.
B1pr27	Project manager requirement to create an overview of the whole process. Depend on whether a project becomes a success or not, that they can see into the future and take it in. Project manager need those human factors necessary to make a flock of people – 20 to 30 people – run together and to decide they enter at the right time. Keep time schedules. Have overview. Make the organization play together. Alpha and omega for project success. A premise that the people involved have capacity, and knowledge including knowledge about marketing sales and the technology to be used in the machines.	Project manager need to create a process overview and need to see into the future and take it in. A project manager is vital for the success of a project. Project manager need to make a flock of 20 to 30 people run together and ensure they enter the project process at the right time. A project manager has to keep time schedules, but this depends on having project personnel with capacity and knowledge about marketing, sales, and technology in the machines.
B1pr28	Inspire. Draw on resource in-house need an overview where to get knowledge from AUC, (Aalborg University) DtU (Denmark Technical University). Overview to see what competence needed in the project Follow the time schedule. Finish projects. Make the project a success	A project manager needs to inspire, draw on in-house or external knowledge when needed and he has to know where to get the knowledge. Identify competences needed. Follow time schedules. Finish projects and make them a success.
B1pr29	Five project managers depending on type of projects either a new product development or an upgrade of existing product	Project management in the studied company split on five project managers depending on what kind of project it is an upgrade or new product development.
B1pr30	People educated in project management, but equally large input from running projects. To be a project manager is not something one can educate for depend on the person and is within one	Even if people are educated in project manager, and equally large input comes from running projects. Being a project manager is not something one can be educated for but is within one.
B1pr31	Technical director ensure qualified project managers. Ensure right distribution of resources	Technical director ensure qualified project managers and a rightly resource distribution, based on what they think is needed to get the project through.
B1pr32	What they think is needed to get a project through	
B1pr33	Project descriptions covers the next 2 to 3 years and related to the strategy for the company	Project description covers 2 – 3 years and related to company strategy.
B1pr34	Strategic plans tell us where we are going development wise, qualification wise. Want to be leading within this industry if not all segments then at least some of them. Some at one time and others at another time. Part of our overall strategy to be in front, but related to how one is in the front. Measure models on weld, related to user friendliness, service, availability, and welding qualities. . How far in the front, are we? How are we in relation to others? The technology used in the machines.	Strategic plans contain information about where the company is going development wise. This involves considering what industrial element the company wants to be leading in, how the company wants to be in front, how far in front the company wants to be, who well do the company do in relation to others and what technology is used in the machines.
B1pr35	Participate in external projects not ground research but close to it. Related to EU projects and with partners from abroad. Users and research institutes participate. Run many throughout the years. A large running now related to welding of aluminium. Have many networks we use. We know foreign institutes were there are persons working with these things and which we benefit from. What happens in the electric arc, the melting bath that is interesting and we can use energy on. Melting bath or the drop transition. The customer do not care about the melting bath, he measures	Participation in external projects both EU projects and with partners. Currently participate in a project to identify how to weld aluminium. Run many of these projects throughout the year and have many networks. Foreign institutes with knowledgeable persons are used with benefit. This is a way of being update within the electric arc welding. Customers do not care about melding baths or where the technology sits, but measure machines according to how they work.

	the experience how does this work. The customer does not care where the technology sits.	
B1pr36	Looks at what we have. Extend the capacity. Do we have the education that is needed?	Look at what we have of knowledge and capacity and consider if more education is needed.
B1pr37	We have middle technicians that can do a job as good as a civil engineer. No specific strategy that this job should be done by a graduate engineer and that job should a technical engineer do. Knows employees" education and what they know and whom we should put on what task.	No particular strategy that identifies that this job should be done by a graduate engineer and that job by a technical engineer. Having knowledge about employees" education and what they know this decided what person to put on what task.
B1pr38	No determined educational strategy for each employee. Yearly appraisals interviews to identify employees" wishes, and to force some employee on courses. Course participation guided by what is relevant for the company. Focus on what project employees work on and what task they have.	Not a determined educational strategy for each employee. Use yearly appraisals interviews to identify employees" wishes and force some to take education.
B1pr39	Sometimes better and more efficient to buy knowledge. Want a particular knowledge within house related to overall strategy, knowledge about the process, and what happens in the welding machine. Be able to develop such a machine ourselves, have full control over the process. Otherwise, purchase a complete machine from a supplier.	Can be more efficient to buy knowledge, but when the company wants to have the knowledge within the house this will be decided in relation to strategy, what knowledge is needed and what developments happens in the welding industry.
B1pr40	Lack of knowledge, a large hurdle than we initially thought.	A large hurdle to overcome the knowledge lack that emerges when an employee suddenly leaves.
B1pr41	Typically when an employee that suddenly disappear.	
B1pr42	Our products consist of hardware and a software part, what knowledge do we need to make the hardware. Unable to make a welding machine having only hardware engineers and hardware technicians. Have the necessary knowledge and competence within the software part. We control consciously to know that we need a certain number of software engineers and hardware engineers. Do we have the competence needed do we have the knowledge needed?	Product consists of hardware and software and making the machines require both types of knowledge. A constant evaluation of what knowledge is needed, and whether the number of engineers is sufficient.
B1pr43	Development group to have an expert inside the development group who is unable to communicate with the development group then we cannot use him If he cannot communicate with the rest of the team, then a less qualified person should have been used. What we have built is not a one-man show.	Expert needs to communicate with the development group otherwise use a less qualified person. Development is not a one-man show.
B1pr44	Know very fast how good the personnel are their qualifications and graduate papers. If they cannot cooperate with others, they are of no value. Introduce an expert a day or two then there is no working in team.	Easy to identify peoples qualifications by reading their graduate papers, but if they are unable to cooperate with others they are of no value and an expert from outside need to be taken in.
B1pr45	How one creates a good environment in the company. To do with how the different humans can make a contribution. For development, personnel need to test boarders, test some new things, attend courses and be educated, be able to get out and look at news for inspiration. Who are the others they work together with, is this flock of inspiring humans, then one lift each other. And, also how are the facilities .I return to the humans, how one can put them together right. How to integrate them.	Building a good environment in the company depend on how the different humans contribute. Development personnel want to test boarders, test new things, attend courses, be educated, and look for inspiration outside company. If these engineers work together with a flock of inspiring humans, they lift each other. The challenges then are how the facilities are and how to put together the right set of people and integrated them.
B1pr46	Few exchanges within the engineers. The engineers over the years get knowledge that is worth its weight in gold.	Engineering knowledge accumulates during the years and this is important to take care of since it is priceless.
B1pr47	Fitness studio, sport association, and an active employee union.	Fitness studio, sports association, and an active employee union are all elements that can help in building a good company culture.
B1pr48	When the facilities are there, people themselves have to decide whether they want to exercise.	Building facilities for employees to use depend on whether they want to use it.
B1pr49	Many pieces are involved in creating a good environment	Building a good company culture is co-play of many things.

In table 12, the left-hand column shows the Id (identifiers), the middle column shows the interview text from the first interview, and the right-hand column shows the key points.

As the next key-point shows, the development strategy in the company is to "aim for the industry segment with the largest market", and "choose either a broad spread of customers or become a specialist supplier".

When it comes to controlling projects it is necessary to follow up on them using "registration, formal follow up meetings giving feedback, use of a product development model, approval decisions based on pre-investigations".

The next key points "product committee meeting where management participates", "approval of phase shifts", "sales, marketing and development heavy involved", and "marketing investigation covers calculations of lifetime, expected sales and costs" describe how progression in the project results from discussions in meetings, approvals, involvement and calculation of products expected lifetime and revenue. Management approves phase shifts by involving sales, marketing, and development The key points "project start-up a co-play of many things", "listen to information from sellers, service and customers", "make a picture", "investigate", "technological development", "alert to happenings in the industry" and "customer demands", describe where to collect information to define a project. A combination of information from sellers, service, and customers identifies a new project. Considering the viewpoints from these actors, create a picture of a potential new project.

Furthermore, the key point "investigate" identifies that the development department do their separate investigations to identify input for new projects, by looking at the potential technological development.

A central key-point summarizing the process towards identifying new projects are: "focusing purposeful on a market segment needing particular welding car-repair and welding rusty body work triggered electric-arc welding development".

The next key-point shows how industry trends are considered when identifying ideas for new projects: "keep eyes and ears open to what happens in the welding industry and what demands the customer makes" the company identifies customer needs. Investigating what happens in the welding industry enables the company to identify strategic decision regarding their market. Consequently, the company focuses purposefully on a market segment in need of a particular type of welding machines. By focusing on a market need can result in development of a complete product program for and industry. Moreover, projects emerge because of the co-play between developments within the industry, market requirements and customer needs.

The key points "customers language", "avoid limited customer groups", "talk to customers what would you pay for something like this", "testing at customer site in the development phase and ask customers in the release phase", "customer involved", "design wise" and "user friendliness", all emphasis the need to listen to customers. It requires attentiveness to what customers say, and to compare customers' needs with the

company strategy. Evaluating customer wishes against the company strategy identifies potential markets for t products and whether the customer represents a limited customer group giving a limited market segment. The dialogue with customers happens in many of the product development phases, and mainly involves issues relating to design and user friendliness.

The key points, "build machines using standard elements to reduce purpose-built", "operation panels easily purpose-built", "better than competitors to use standard elements in a smart and rational way", "a welding machine not a mass product, batch production", "largest machine sold around 1000 pro anno", "ability to produce is no restriction", and "production runs linear", describe how the company achieves flexibility in production. The company achieves production flexibility by using standard components, and by reducing purpose-built machines production. However, some elements such as operation panels can easier be purpose built, and fitted to the individual customer's needs. Even if production in the company focuses on production in large numbers, a welding machine is not a mass product and the product line is linear batch production. Furthermore, the company runs an integrated product development model where the involvement of departments in the development process, vary in intensity. The company aims to increase flexibility and reduce the amount of purpose-built products with the use of standard elements to get a smart and efficient production.

The key points, "sales department included", "all functions participate in the development process all the time", "sales present ideas for project but also the economy in them", "marketing included discussing design, manuals, spare part lists and brochures" "participation by other departments varies in intensity" and "early appointment of project manager and runs the project until completion", refer to how participation in the product development group is viewed. In principle, inclusion of all functions in the product development group varies in intensity.

The key points, "difficult to get a project manager that can run a project until completions and have overview of the product development process", "specialist can be found but competent projects managers less easy to find", "being a project manager should be part of one and it depend on experience and what one has learned to keep a product development process going", "project manager needs to create a process overview and need to look into the future and take it in competent personnel versus overview", "project manager measured according to the project a success or not", "a project manager needs to inspire, draw on in-house or external knowledge when needed and he has to know where to get the knowledge from need to make a flock of 20 to 30 people run together and ensure they enter the project process at the right time", "identify competence needed", "follow time schedules", and "finish projects and make them a success" identifies the requirements to a project manager.

In the next key-point, “project management split on five project managers depending on what kind of project it is, an upgrade or new product development”, describes how project responsibility is handled in the studied company. The technical director appoint project managers to projects to: “ensure qualified project managers and a rightly resource distribution, based on what they think is needed to get the project through”.

The next key-points show some of the expectations to a project manager. Hence, a project manager, even with a formal “project management education”, need to be able to “learn from practice”, therefore one can “not educate a project manager”, but the project manager need to have a “project manager within”. Running projects are equally as important as education to be a project manager “even if people are educated in project manager, and equally large input comes from running projects”. A project manager thus needs “knowledge, education and practical experience” (B1pr37). Furthermore, the personality of a person decides who will be a good manager. Hence “being a project manager is not something one can be educated for but is within one”.

The key points in B1pr33, B1pr34, B1pr35, and B1pr36 describe how strategic plans guide the development processes in the company. A strategic plan gives the direction of the company’s development process and describes the competences necessary to achieve the strategy. A strategic plan describes in which market segments the company must be in front in, and how to achieve this. The strategic plan involves measuring welding related to factors such as user friendliness, service, availability, and welding qualities. Hence “project description covers 2–3 years and relates to company strategy”, and “this involves considering what industrial element the company wants to be leading in”. Typical questions to considered are: “how far are we in front, who are we in relation to others and what technology is used in the machines”.

As the following key-points show, representatives from development department in the company participate in EU projects, and in projects with external partners such as foreign institutes, in order to get new knowledge, and be updated on progression in the field. The development department benefits from external project participation when working with “foreign institutes with knowledgeable persons, these are used with benefit for the company”. Throughout a year, the company runs many such projects providing with “many networks”. The many networks update the company with knowledge “within electric-arc welding”.

The following key points, B1pr38, B1pr39, B1pr40, B1pr42, B1pr43, and B1pr44, describe the knowledge needed by the development department to develop the machines. Machine performance is a central issue that needs to be considered during development of a machine because, “customers do not care about melding baths or where the technology sits, but measure machines according to how they work”.

The key-point, “no particular strategy identifying that this job should be done by a graduate engineer, and that job by a technical engineer”, shows how distribution of development jobs is handled. Having “knowledge about employees education ”, and what “employees’ know”, decide “what person to put on what task”. Furthermore, individuals build competence when they change job tasks.

Deciding what knowledge employees have is based on evaluating them individually by looking at their education, and their skills. Employees’ knowledge is easy to identify, because the company know their education. Furthermore, employees get assigned to new tasks depending on what previous projects and tasks they have worked on.

However, there seem to be no educational strategy for each employee, “not a determined educational strategy for each employee”. Employees’ education, knowledge, and skills are identified in an appraisal interview (id Bja57). Hence, yearly appraisals interviews are conducted “to identify employees wishes, and force some to take education”. Appraisals interviews identify what knowledge each employee needs. Either employee’s knowledge is update, by giving them more education, or the company buy knowledge externally. In some cases, employees participate on courses aimed at providing them with knowledge, which comply with the overall strategy for the company.

The company evaluates their development strategy to identify whether they have enough knowledge about the welding machine process to develop a machine themselves, and if they are able to control the development process.

The company needs to consider what happens, when they supply knowledge to the development group from another part of the company, by having an expert inside the group. However, an internal expert who is transferred to a development group needs to be able to communicate with the group. If the expert is not able to communicate with the members of the development group, then a less qualified person substitutes an expert, because, product development is teamwork, and not “a one man show”. Employees are expelled from the development department when they are unable to collaborate with others.

The key point, “knowledge lack hurdle”, identifies the challenge facing the company when an employee leaves. Moreover, when an employee leaves, a knowledge lack is created and for the company it becomes, “a large hurdle”, to gain the lost knowledge.

Since all welding machines consist of hardware and software, a production of welding machine requires not only hardware engineers and hardware technicians, but also engineers and technicians with software knowledge. The development department

continuously control if they have the needed number of software and hardware engineers, up against the competence and knowledge needed to develop a machine.

The key points, “building a good environment in the company depends on how the different humans contribute”, “development personnel need to test boarders, test new things, attend courses, be educated and look for inspiration outside the company”, and “if these engineers work together with a flock of inspiring humans they lift each other”, explain what contributes to a good environment in the company. For the development personnel a good environment means to be able to test boarders, have opportunities to attend courses, and to be able to get outside the company for new inspiration. Subsequently, it is necessary to consider what facilities the development personnel have, who else the development personnel work together with, and how “to put together the right set of people and integrated them”.

The key point, “engineering knowledge accumulates during the years, and it is important to take care of since it is priceless,” demonstrate that the company is aware of the importance of taking care of personnel with knowledge, and to stimulate their knowledge building.

Over the years, the engineers accumulates knowledge by allowing to work together as a group, with only few exchanges to other project groups. This approach is seen as, “worth its weight in gold”, since it allow employees to be specialists.

The key-points, “fitness studio, sports association, and an active employee union are all elements that can help in building a good company culture”, “depends on whether they want to use these facilities”, “building a good company culture is a co-play of many things”, demonstrate some of the factors that help to build a good company culture. However, the success of these elements will depend on whether employees find them useful and satisfying.

6.2 From Key Points to Codes in the First Interview

Table 14 shows the process from key points to codes. In table 15, the left-hand-column represents the identifiers as before, the middle-column represents the key points, and the right-hand-column represents the codes.

In order arrive at codes, based on the key points, I first grouped together all the key points with a similar content, or meaning. What key-points are grouped together can be seen by looking at the Id (identifiers), which belongs to the same codes. Furthermore, to improve readability, I have purged all those instances where the same words occurred several times describing the same phenomenon.

Typically “knowledge harvesting”, describe processes where knowledge is gained, when “knowledge harvesting” as a phrase occur several times in the grouped codes, the term “knowledge harvesting “will only be mentioned once.

Merging of codes happens when they have the same meaning, or the same use of phrases or words. By merging codes, aggregation of data reaches the next level in the GTIA method. By applying these adjustments to all the interviews, the GTIA moves from key points to codes.

Table 13: Table showing coding from key points to codes in first interview

Id	Key Points	Codes
B1pr2	Not a large company reasonable control on everything. Delegate responsibility for project parts	Company size and delegation of project responsibility gives control.
B1pr4	Run projects to bring the company forward either, technically through new developments, bring products up to the state-of-the–art, give old products a technical lift, heavy projects run over several years, short projects to lift products to market standard	Projects should bring the company forward technically or update products to lift them to market standard or state-of-the-art.
B1pr5, B1pr6 B1pr8, B1pr14	Electric arc welding constitutes 80-90% of their development. Aim for the industry segment with the largest market. Choose either a broad spread of customers or become a specialist supplier. Focusing purposeful on a market segment needing particular welding car-repair and welding rusty bodywork triggered electric-arc welding development. Look at trends in the industry to discover customer needs.	Identify the industry segment with the largest market, and focus purposefully by choosing a broad spread of customers or be a specialist supplier.
B1pr11	Controlling projects through registration, formal follow up meetings giving feedback, use of a product development model, approval decisions based on pre-investigations.	To control projects they are discussed in formal meetings and supervised by a formal product development model.
B1pr12	Product committee meeting where management participates. Approve phase shifts. Sales, marketing and development heavy involved. Marketing investigation covers calculations of lifetime, expected sales, and costs.	Management at each phase in the development model takes approval decisions. Decisions based on calculation of product lifetime, expected sales, and costs.
B1pr13	Project start up a co-play of many things. Listen to information from sellers, service, and customers. Make a picture. Investigate. Technological development. Alert to happenings in the industry. Customer demands	Starting a project based on input from sellers, customers, service, technological development, and industry developments.
B1pr15, B1pr16	Customers' language. Evaluate what is a market for us focus on large consumption market. Avoid limited customer groups. Talk to customers what would you pay for something like this. Testing at customer site in the development phase and ask customers in the release phase. Customer involved in many product development phases, both design wise and related to user friendliness.	Customers are involved in many of the development phases in terms of design of user-friendly machines. Need to understand the customers language, but avoid develop machines for limited customer groups.
B1pr17, B1pr18 B1pr19, B1pr20 B1p21	Build machines using standard elements to reduce purpose-built. Operation panels easily purpose-built. Better than competitors to use standard elements in a smart and rational way. A welding machine is not a mass product, but a batch product. Largest machine sold around 1000 pr. anno. Ability to produce is no restriction. Production runs linear.	Focus on building machines based on standard elements to avoid purpose-built machines. Building a welding machine is based on batch production, using standard elements in a rational and smart way.
B1pr22, B1pr23 B1pr24	Sale included in the product development process all the way. All functions participate in the development process all the time. Sales present ideas for project but also the economy in them. Marketing included discussing design, manuals, spare part lists, and brochures. Participation by other departments varies in intensity. Project manager appointed early and runs the project until completion.	Sales included in the development process all the way and present ideas for the project and the economy in them. Participation by other departments varies in intensity.

B1pr25, B1pr26 B1pr27, B1pr28, B1pr29, B1pr30	Difficult to get a project manager that can run a project until completions and have overview of the product development process. Specialist can be found but competent projects managers less easy to find. Being a project manager should be part of one and it depending on experience and what one has learned to keep a product development process going. Project manager need to create a process overview and need to see into the future and take it in. A project manager is vital for the success of a project. Project manager need to make a flock of 20 to 30 people run together and ensure they enter the project process at the right time. A project manager has to keep time schedules, but this depends on having project personnel with capacity and knowledge about marketing, sales, and technology related to the machines. A project manager needs to inspire, draw on in-house or external knowledge when needed and he has to know where to get the knowledge. Identify competences needed. Follow time schedules. Finish projects and make them a success. Project management in the studied company split on five project managers depending on what kind of project it is an upgrade or new product development. Even if people are educated in project manager, and equally large input comes from running projects. Being a project manager is not something one can be educated for but is within one.	A project manager is something that should be within a person. A project manager has project overview and is able to look into the future and take it in. Being a project manager depend on experience and what one has learned to keep a development process going. A project manager has to keep time schedules, make the project a success, and have project personnel with capacity and knowledge about marketing, sales, and technology related to the machines. A project manager needs to inspire the development team, and be able to collect and know where to collect knowledge when it is needed. People can have a project manager education, but equally important that they have been running projects. Being a project manager is not something one can be educated for.
B1pr31	Technical director ensure qualified project managers and a rightly resource distribution, based on what they think is needed to get the project through.	Qualified project managers are appointed by the technical director including ensuring the right distribution of resources.
B1pr33	Project description covers 2 – 3 years and related to company strategy.	A project description covers 2-3 years.
B1pr34	Strategic plans contain information about where the company is going development wise. This involves considering what industrial element the company wants to be leading in, how the company wants to be in front, how far in front the company wants to be, who well do the company do in relation to others and what technology is used in the machines.	Strategic plans contain information of the company's development direction. This information displays what industrial segments the company wants to be leading in, how the company wants to be in front, how far in front, how well company performs in relation to competitors and the technology used in machines.
B1pr35	Participation in external projects both EU projects and with partners. Currently participate in a project to identify how to weld aluminium. Run many of these projects throughout the year and have many networks. Foreign institutes with knowledgeable persons are used with benefit. This is a way of being update within the electric arc welding. Customers do not care about melding baths or where the technology sits, but measure machines according to how they work.	Participation in more research related projects EU projects, project with partners or with foreign institutes give new knowledge and networks. Provide an opportunity to be updated on recent technology and access to knowledgeable persons. Customers not particular interested in where the technology sits but how the machine works.

B1pr36, B1pr37 B1pr38, B1pr39 B1pr40, B1pr42 B1pr43, B1pr44 B1pr46	Look at what we have of knowledge and capacity and consider if more education is needed. No particular strategy that identifies that this job should be done by a graduate engineer and that job by a technical engineer. Having knowledge about employees' education and what they know, decided what person to put on what task. Not a determined educational strategy for each employee. Use yearly appraisals interviews to identify employees' wishes and force some to take education. Can be more efficient to buy knowledge, but when the company wants to have the knowledge within the house this will be decided in relation to strategy, what knowledge is needed and what developments happens in the welding industry. A large hurdle to overcome the knowledge lack that emerges when an employee suddenly leaves. Product consists of hardware and software and making the machines require both types of knowledge. A constant evaluation of what knowledge is needed, and whether the number of engineers is sufficient. An expert need to communicate with the development group otherwise uses a less qualified person. Development is not a one-man show. Easy to identify peoples qualifications by reading their graduate papers, but if they are unable to cooperate with others they are of no value and an expert from outside need to be taken in. Engineering knowledge accumulates during the years and this is important to take care of since it is priceless.	Through appraisals interviews identify what education the employees want and who need to take more education. Both the company strategy and the knowledge the company possesses influence what further upgrade in knowledge is needed amongst employees. Both education and practice influence what person is put on what task in the company. In some cases can be more efficient to buy knowledge, if the knowledge needed is not something the company wants to have in-house. Since machines consists of a hardware and a software part, it is necessary to ensure that the company have the right number of engineers with these types of knowledge, since product development is not a one-man-show. Engineering knowledge accumulates over the years making it priceless, and when personnel leave it is a large hurdle to overcome the knowledge lack. If those with knowledge, either from in-house or from external are unable to cooperate and communicate with others, then they are of no use.
B1pr45 B1pr47 B1pr48 B1pr49	Building a good environment in the company depend on how the different humans contribute. Development personnel want to test boarders, test new things, attend courses, be educated, and look for inspiration outside company. If these engineers work together with a flock of inspiring humans, they lift each other. The challenge then is how the facilities are and how to put together the right set of people and integrated them. Fitness studio, sports association, and an active employee union are all elements that can help in building a good company culture. Building facilities for employees to use depend on whether they want to use it. Building a good company culture is co-play of many things.	A good environment consists of putting together a team of inspiring humans that can lift each other. Facilities such as fitness studio, sports association, and an active employee union help in building a good company culture. The challenge is whether employees will use such facilities and how to put together the right set of people and integrate them. Building a good company culture is a co-play of many things.

In table 14 the left-hand column contain the Id (identifiers), the middle-column the key points and the right-hand column the codes. The number of the identifiers, Id, will not be chronological as the questions and comments from the interviewers are removed from the original interview text.

The first two codes to emerge in table 13 are "company size", and "delegation of project responsibility gives control", both with the id B1pr2. Together these codes explain how project control, is related to both the size of the company, and the delegation of the responsibility for different parts of a project. Furthermore, "to control projects they are discussed in formal meetings and supervised by a formal product development model". This code illustrates the need for procedures to control development projects develop. Using an integrated product development model (IPD) involves, following up project activities, holding formal meetings to give feedback, and to use approval of decisions to control progression in projects. Hence, using a development model ensures the technological development of machines, and the renewal pace of products.

The code, "identify the industry segment with the largest market, and focus purposefully either by choosing a broad spread of customers or be a specialist supplier heavy projects", describes what considerations the company make in order to identify the market for their products.

The next code, "projects should bring the company forward technically or update products to lift them to market standard or state-of-the-art", describe how the latest technological developments will give products a technical lift, and bring the product development projects up to market standard, in relation to comparable market products.

The codes, "to control projects they are discussed in formal meetings and supervised by a formal product development model", "approval decisions are taken by management at each phase in the development model", "decisions based on calculation of product lifetime, expected sales and costs", describe some of the discussions and decisions influence a project. Approval of projects happens in formal meetings in the product committee, with representatives from all departments in the company who are involved in the project, including management participants. Subsequently, whether to proceed with the project to the next phase depends on approval of the sales investigations of, the costs and the calculation product lifetimes. Lack of approval from the product committee based on the supplied documentation, the project will not proceed to the next phase and need to find answers to those questions the committee members pointed out as unanswered.

The codes, "customers are involved in many of the development phases in terms of design of user friendly machines", "customers not particular interested in where the technology sits but how the machine works", "need to understand the customers language, but avoid develop machines for limited customer groups", and "focus on

building machines based on standard elements to avoid purpose-built machines", describe some of the customer considerations made when developing a product. In order to create an accurate picture of how to develop a product, information from sellers, service, and customers are considered. Additionally, "sales are included in the development process all the way and present ideas for the project and the economy in them", and "participation by other departments varies in intensity". Furthermore, it is necessary to include the information collected through marketing's investigations of technological developments, industrial developments, and customer demands.

The code, "building a welding machine is based on batch production, using standard elements in a rational and smart way", describe how production is organized in order to reduce the amount of purpose built machines, by using more standard elements. By using standard elements smart and rationally, the production process becomes more efficient. However, machines can still be purpose built through adjusting their operation panels, which are much easier to purpose build.

The code, "project membership", describes the degree and intensity of participation in projects, by the different departments. In some phases of the project, participation can be more intense, because critical elements are added to a machine. However, some phases of the development process can be less intense, because the main contributions have already been made, or they will be made later in the development process. Nonetheless, membership in a project might vary according to the "project type". Therefore, completely new products might require more intense involvement of all potential contributors, while an upgrade of a project requires less involvement.

The codes, "a project manager is within a person", "a project manager has project overview and is able to look into the future and take it in", "being a project manager depend on experience and what one has learned to keep a development process going", "a project manager has to keep time schedules, make the project a success, have project personnel with capacity and knowledge about marketing, sales and technology related to the machines", "a project manager needs to inspire the development team, and be able to collect and know where to collect knowledge when it is needed", "people can have a project manager education, but equally important that they have been running projects", "being a project manager is not something one can be educated for", and "qualified project managers are appointed by the technical director including ensuring the right distribution of resources", describe what qualifications a project manager shall posses. A project manager shall be able to keep an overview of the whole product development process. He shall be able to read the future and act accordingly. He shall be able to keep time schedules and get the right personnel to do product development at the right time and to finish the project. A project manager is successful if the project he or she is responsible for has success. A project manager must identify the competencies needed in

a project, and be able to involve personnel with capacity and knowledge to perform their project tasks. A project manger needs marketing, sales, and technological, knowledge. A project manager should be able to inspire the personnel and make them co-play.

The code, "becoming a project manager", with id B1pr30 and B1pr31, summarizes what requirements a project manager needs to become a qualified project manager. A project manager needs education, and to be able to learning from practice. Therefore, knowledge, education, and experience identify who becomes a project manager, but also what project manager gets what tasks. A good project manager is an intrinsic part of a person's personality.

The codes, "strategic plans contains information of the company's development direction", "this information displays what industrial segments the company wants to be leading in, how the company wants to be in front, how far in front, how well company performs in relation to competitors and the technology used in machines", identify the strategic factors influencing the product development projects. Typically, a project plan, covers the next 2 – 3 years, and is related to the overall strategic plan for the company. A strategic plan defines those market segments where the company wants to be in front, i.e. take a market leading position. Moreover, a strategic plan considers how far in front the company wants to be, based on measuring their service availability, machines welding qualities, machines user friendliness in relation to competitors, and the novelty of technology used. To be in front the company must be updated on welding qualities, and technology. Through "participation in more research related projects EU projects, project with partners or with foreign institutes give new knowledge and networks", and an opportunity "to be updated on recent technology and access to knowledgeable persons". Knowledge about welding and the latest progression within welding are some of the benefit the company achieve from their participation in EU funded projects as well as in projects with foreign and domestic research and educational institutions. These collaborations require the company to consider their own in-house qualifications. Moreover, to identify if the company requires more production capacity or better educated personnel.

The codes, "through appraisals interviews identify what education the employees want and who need to take more education", "both the company strategy and the knowledge the company possesses influence what further upgrade in knowledge is needed amongst employees", "both education and practice influence what person is put on what task in the company", "in some cases can be more efficient to buy knowledge, if the knowledge needed is not something the company wants to have in-house", "since machines consists of a hardware and a software part, it is necessary to ensure the right number of engineers with these types of knowledge, since product development is not a one-man-show", "engineering knowledge accumulates over the years making it priceless,

and when personnel leave it is a large hurdle to overcome the knowledge lack", "if those with knowledge, either from in-house or external are unable to cooperate and communicate with others, then they are of no use.", describe what factors influence knowledge acquisitions. To define individuals' educational strategy the company considers employees' wishes up against the relevance of further education for the company, and for project tasks. The company continuously considers whether to buy, or to develop, knowledge in–house, in order to get full control of the product development process.

The codes, "a good environment consists of putting together a team of inspiring humans that can lift each other", "facilities such as fitness studio, sports association and an active employee union help in building a good company culture", "the challenge is whether employees will use such facilities and how to put together the right set of people and integrate them", and "building a good company culture is a co-play of many things define how a good environment relies on giving the development personnel possibility to test new things, attend courses, be educated, and to look for inspiration outside the company. However, the challenges lie in ensuring that employees use these facilities, and to ensure that the right people are put together in projects where they can inspire each other.

6.3 From Codes to Concepts in the First Interview

In order to reach the next step in the data analysis, the codes are aggregated to concepts. During the aggregation of codes, they reach a higher level of commonality by grouping all codes from all interviews together, and defining the codes as concepts. As the following tables will demonstrate, some codes appear several times in the different tables. Codes appearing several times in the table demonstrate how the accumulation process grounds the data, and this is a natural evolvement when doing grounded theory.

The codes from the interview describe how the company size and delegation of project responsibility gives project control. The reason for doing product development projects is to bring the company forward technically or update products to lift them to market standard as state-of-the-art products.

In addition, it is necessary for the company to have some strategic focus in its development process. Hence, identify the industry segment with the largest market, and focus purposefully on developing products, by choosing a broad spread of customers or be a specialist supplier.

To start up a project requires different types of input from different sources. Starting a project based on input from sellers, customers, service, technological development and industry developments.

Once projects are underway, it becomes important to control them. Therefore, "to control projects", they are discussed in formal meetings and supervised by a formal product development model. However, project control also depends on making the right decisions. Consequently, management at each phase in the development model takes approval decisions. These decisions are based on calculation of product lifetime, expected sales, and costs.

Customers' involvement in the development phases, are related to discussions on design issues such as user-friendliness. Therefore, to avoid developing machines for limited customer groups it is necessary to understand the customer's language. Customers want to know how the machine works, not where in the machine the technology is implemented. Therefore, to avoid building machines for specific users, the company uses batch production. With batch production the company is able to use standard elements to get an efficient, rational and smart production, but at the same time they can adjust machines to specific customers when this is required.

When it comes to inclusion of different personnel from different departments, the degree and timing of inclusion varies. Hence, "sales included in the development process all the way and present ideas for the project and the economy in them, while participation by other departments varies in intensity".

During a product development, process the project manager assumes extra responsibility for the product development process, and consequently the requirements to the project manager changes.

> "A project manager is within a person. A project manager has project overview and is able to look into the future and take it in. Being a project manager depend on experience and what one has learned to keep a development process going. A project manager has to keep time schedules, make the project a success, and have project personnel with capacity and knowledge about marketing, sales, and technology related to the machines. A project manager needs to inspire the development team, and be able to collect and know where to collect knowledge when needed. People can have a project manager education, but need to be able to run projects. Being a project manager is not something one can be educated for. Qualified project managers are appointed by the technical director, which also involves ensuring the right distribution of resources".

Normally, a project description covers 2-3 years. In addition to project, plans for the individual project there are strategic plans. Strategic plans contain information about the company's development direction. The information displays what industrial segments the company wants to be leading in, how the company wants to be in front, how far in

front, how well company performs in relation to competitors and the technology used in machines.

Participation in external projects or collaborations provides new knowledge and updates the development group on development within welding. Hence, participation in more research related projects such as EU projects, project with partners or with foreign institutes, gives new knowledge, and networks. Research projects provide an opportunity to update their knowledge on recent technology and get access to knowledgeable persons.

Acquisition of knowledge, and identification of knowledge needs, is important. Appraisals interviews identify what education the employees want and who needs to take more education. Both the company strategy and the knowledge the company possesses influence what further knowledge upgrade employees need. Assigning persons to tasks happens by considering both their education and practice.

In some cases, buying knowledge is more efficient, if the company do not want to have the knowledge in-house. Since machines consist of hardware and a software part, it is necessary have the right number of engineers with relevant knowledge, because product development is not a one-man-show.

Engineering knowledge accumulates over the years making it priceless, and when personnel leave overcoming knowledge lacks represents a large hurdle. If those with knowledge, either from in-house or from external are unable to cooperate and communicate with others, then they are of no use.

Having knowledge and operate the development process efficiently can only be fully achieved if there exist a good working environment. “A good environment consists of putting together a team of inspiring participants. Facilities such as fitness studio, sports association, and an active employee union help in building a good company culture. The challenge is whether employees will use such facilities and how to put together the right set of people and integrate them. Building a good company culture is a co-play of many things”.

The concepts in table 15 below deal with, “development control”, “orientation of development””, and extent of development, duration of projects “”, development and delivery pressure” and “controlling projects”. These are all concepts that influence product development projects progression. While the concept, “achieving a development philosophy” defines what the overall consideration for the product development process is. The concept “slow product development” refers to the time it takes new products to hit the market. The market within the welding machine production has few product renewals, because the technological development is slow.

Table 14: Table showing coding from codes to concepts

Id	Codes	Concepts
B1pr2	Company size and delegation of projects gives control	Development control
B1ja3, B1ja4, B1ja5, B1ja6, B1ja7, B1ja8	Orientate product development	Orient product development
B12pr, B1pr34k B2ja34	Development direction	
	Development considerations	Development considerations
	Extent of development	Extent of development
	Project duration	Duration of projects
B1ja9, B1ja10	Development pressure	Development and delivery pressure
B4jp10, B4jp11, B4jp12	Delivery pressure	
B1pr11	Controlling projects	Controlling projects
B3ob33, B3ob37	Pulling the handbrake for development	
B2ja33, B2ja42, B2ja43, B2ja44, B2ja45	Development philosophy	Achieving a development philosophy
B1ja1	Slow product development	Slow product development
B1ja2	Few product renewals	
B1ja3, B1ja4, B1ja5, B1ja6, B1ja7, B1ja8	Product renewals	
B1ja11. B1ja18, B1ja21, B1ja22, B1ja25	Organizing for output	Organizing for output
B1ja12, B1ja17	Dynamic planning	Dynamic planning
B3ob22	Idea evaluation	Idea evaluation
B4jp15, B4jp26, B4jp16, B4jp17, B4jp18, B4jp19, B4jp31, B4jp32	Control production capacity	Control production capacity and reduce order processing
	Reduce order processing time	
B1ja13, B1ja14	Business orienting personnel	Stimulate and regulate employees behaviour
B4jp28, B4jp29, B4jp30	Conduction of regular meetings	
B1ja31, B1ja33, B1ja37, B1ja38	Motivations for participation	
B2ja58, B2ja59, B2ja60	Knowledge development	
B4jp2, B4jp3, B4jp07	Violation of product development	Violation of product development
B4jp9, B4jp40	Communication lack consequences	

The concepts “slow product development” refers to the pace of product development related to the products produced by the firm. Meaning that there is not a fast product development where new products with new functionalities or looks flood the market at a quick pace.

The concept “organizing for output”, “dynamic planning”, “idea evaluation” and “stimulate and process in a way that stimulate employees and where ideas are evaluated, but at the same time regulate employees behaviour.

The concept “violation of product development” refers to how communication lacks will jeopardize the product development process.

The concept, “achieving a development philosophy”, refers to the idea of an underlying philosophy in the product development process. Such development philosophy penetrates all product development done in the company.

In order to do product development as efficient as possible both “organizing for output”, “dynamic planning”, “control production capacity and reduce order processing” is necessary. Additionally, the personnel have to be business oriented, holding regular meetings, stimulate employees’ motivation and knowledge, and regulate employees’ behaviour.

In table 16 below the concepts “forwarding projects”, “arguing for a project”, “focus on the smallest NPV (New Product Value)” and “output something physical” all refers to those processes and considerations that will promote a particular project. In order to finance product development “ensuring flagship products” is necessary. These products are the breadwinners for other product development projects as long as they are not standard products.

Table 14: Table showing coding from codes to concepts (continued)

Id	Codes	Concepts
B1pr4	Forward projects	Forwarding projects
B1ja69, B1ja70, B1ja71, B1ja72, B1ja73, B1ja74	Arguing in a projects favour	Arguing for a project
B2ja74, B2ja75, B2ja76, B2ja77, B2ja78, B2ja79, B2ja80, B2ja82, B2ja83, B2ja84, B2ja85, B2ja86, B2ja87	Smallest NPV (New Product Value)	Focus on the smallest NPV (New Product Value)
B4ob7	Product output something physical	Output something physical
	Break things into smaller units	Break things into smaller units
B4ob106, B4ob107, B4ob108	Need for a flagship product	Ensuring flagship products
B4ob12	Variant issues	Variant issues
B4ob68, B4ob69, B4ob70, B4ob71	Design issues	Design issues
B1ja40, B1ja42, B1ja43, B1ja45, B1ja46, B1ja47, B1ja48	Compliance criteria	Compliance criteria
	Translate requirements into practice	Translate requirements into practice
	Objective criteria	Identify objective criteria
B2ja25	Requirement compliance	
B2ja74, B2ja75, B2ja76, B2ja77, B2ja78, B2ja79, B2ja80, B2ja82, B2ja83, B2ja84, B2ja85, B2ja86, B2ja87	Business analysis	Business analysis
B2ja90, B2ja91, B2ja92, B2ja93, B2ja94, B2ja95, B2ja99, B2ja100, B2ja103	Budget considerations	Budget considerations
	Long term budget thinking	
	Needed growth	
B4kjp34, B4kjp35, B4kjp36	Estimating the product cost price	Price considerations
B4ob91, B4ob92, B4ob93, B4ob94	Price discussions	
B4ob121, B4ob122, B4ob123, B4ob125, B4ob126, B4ob127	Ensure payoff	
	Hit right in the market	
B4ob130, B4ob131, B4ob132	Need a qualitative right product	
B4kjp38, B4kjp49, B4kjp41	Reduction of variants	
B4kjp40	Lock wishes	

In the product development process, both issues concerning the number of variants "variant issues" and discussions concerning "design issues" influence the efficiency of the process. In order to deal with the design issues it is necessary to define a set of "compliance criteria", which are objective and to "translate requirements into practice". The last concepts in table 16 refer to aspects of the product development process dealing with economy. It is necessary to analyze the business to make "budget considerations" as well as "price considerations". These considerations require both long-term budget thinking, focus on the needed growth, an estimate of the product cost price, and discussions concerning product price. The purpose of these economic considerations is to

ensure payoff and to hit the market with a qualitative right product. These discussions also help in reducing the number of variants and lock product wishes.

Conducting a thorough data analysis represents the core of a grounded theory inspired approach (GTIA). The epistemological view taken by the researcher will influence the research. Application of GTIA emphasises product development as a social dynamic process driven by individuals' interpretations. In chapter 7, the final step of the data analysis, development of the final categories is explained.

6.4 From Concepts to Categories in the First Interview

In order to reach the final step in the data analysis, the concepts are aggregated to categories. The aggregation of data ends up in categories, the data have been saturated enough in order to reach their final theoretical descriptions.

The first category, "project emergence", describes those considerations taken in order to decide what projects to start developing.

The second category, "development requirements", defines what those elements that need to be considered in order to define the requirements to products.

The third category, "business considerations", explains what elements are evaluated in order to decide if there is money to be earned on developing the product.

The fourth category, "market considerations", defines what is necessary to take into consideration in order to hit right with the product in the market, and ensure that products generate revenues.

The fifth category, "variant issues", defines what considerations are made in order to reach a manageable number of projects in the development department.

Table 15: Table showing coding from concepts to categories.

Id	Concepts	Categories
B1pr4	Forward projects	Project emergence
B1ja69, B1ja70, B1ja71, B1ja72, B1ja73, B1ja74	Arguing in a projects favour	
B2ja74, B2ja75, B2ja76, B2ja77, B2ja78, B2ja79, B2ja80, B2ja82, B2ja83, B2ja84, B2ja85, B2ja86, B2ja87	Smallest NPV (New Product Value)	
B4ob7	Product output something physical	Development requirements
	Break things into smaller units	
B4ob106, B4ob107, B4ob108	Need for a flagship product	
B4ob12	Variant issues	
B4ob68, B4ob69, B4ob70, B4ob71	Design issues	
B1ja40, B1ja42, B1ja43, B1ja45, B1ja46, B1ja47, B1ja48	Compliance criteria	
	Translate requirements into practice	
	Objective criteria	
B2ja25	Requirement compliance	
B2ja74, B2ja75, B2ja76, B2ja77, B2ja78, B2ja79, B2ja80, B2ja82, B2ja83, B2ja84, B2ja85, B2ja86, B2ja87	Business analysis	Business considerations
B2ja90, B2ja91, B2ja92, B2ja93, B2ja94, B2ja95, B2ja99, B2ja100, B2ja103	Budget considerations	
	Long term budget thinking	
	Needed growth	
B4kjp34, B4kjp35, B4kjp36	Estimating the product cost price	
B4ob91, B4ob92, B4ob93, B4ob94	Price discussions	
B4ob121, B4ob122, B4ob123, B4ob125, B4ob126, B4ob127	Ensure payoff	
	Hit right in the market	Market considerations
B4ob130, B4ob131, B4ob132	Need a qualitative right product	
B4kjp38, B4kjp49, B4kjp41	Reduction of variants	Variant issues
B4kjp40	Lock wishes	

In this chapter, the coding process using a GTIA (Grounded Theory Inspired Approach), have been demonstrated for one interview. The complete data analysis is described in Appendix IX. This coding process has led to the aggregation of five categories, project emergence, development requirements, business considerations, market considerations, and variant issues.

7. Categories Produced from the Data

In this chapter, I use the empirical data analysis in chapter 6 to develop nine categories. The nine categories are:

1. Project emergence,
2. Strategic Considerations,
3. Flexible and Coordinated Project Planning,
4. Binding to Market,
5. Inclusion on demand,
6. Project Manager Compliance,
7. Production Flexibility,
8. Cultural Traits,
9. Knowledge Harvesting.

These nine categories identify the factors, and decisions inducing the learning processes taking place during product development in the studied company as experienced by the participants. I define learning as processes where information is shared, discussed, and interpreted. By viewing learning as processes, I look at how employees solve problems by discussing, engaging in collaborations, and gathering information followed by distribution of information, and acquisition of knowledge within and outside the organization. Furthermore, such a view on learning emphasises what processes are best fit to make use of the knowledge in the organization, in order to find local solutions to local problems (Pålshaugen, 1992).

In order to identify these learning processes I have used the coding paradigm developed by Strauss (2003) as a guide. Strauss (2003) recommends applying this coding paradigm to identify why, and how employees' leaning processes occur. His coding paradigm emphasis the following four elements in the data during coding[1]:

1. Conditions
2. Interaction among the actors
3. Tactics and strategies
4. Consequences (Strauss, 2003: 27-28).

Conditions are according to Strauss (2003), found by looking for words like "because", "as", "on account of", or "since". Interactions among actors are those actions that are not straightforward from tactics or strategies. Tactics and strategies define what actions persons take. Consequences are identified by looking for cues such as "because of that", "the result was", "the consequence was", or "in consequence".

According to Strauss, using the coding paradigm is necessary for coding to be coding (Strauss, 20003: 27-28). Moreover, since my thesis emphasis learning as a social process, it

[1] These four elements are highlighted in italic in the analysis in this chapter.

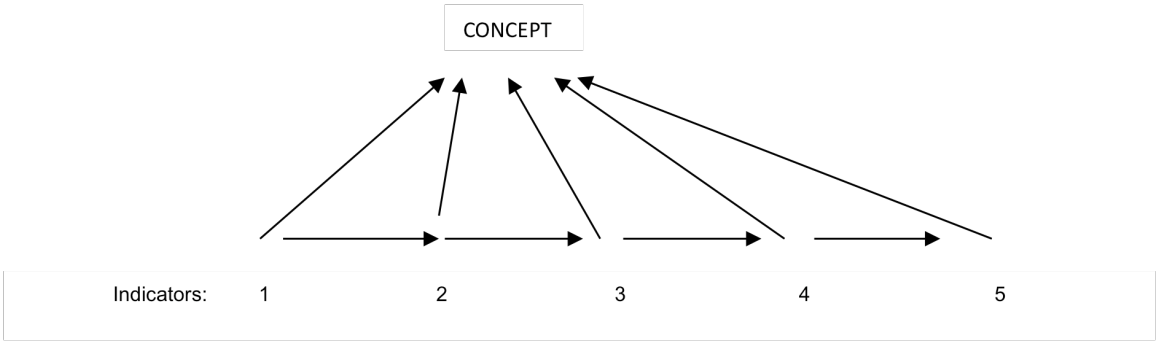
is necessary to look for the three characteristics of "symbolic interactionsim" in the data:

1. "That people act towards things based on the meaning they have to them.
2. That the meanings people attach to things derive from a social interaction with others.
3. That meaning moulds in a reflective process as the individual deals with the 'things' encountered"(Blumer, 1998; 2).

In addition I use a "concept-indicator model" to ensure the re-integration of data (Strauss, 2003: 25). The "concept-indicator model", recommended by Strauss (2003), emphasis how Grounded Theory (GT) broadens and re-integrate where other traditions such as structured interviews narrows and dense the data.

In this chapter, I use the "concept- indicator model" (Strauss, 2003: 25) to integrate the indicators belonging to each concept.

Figure 8: Concept-indicators model adapted from Strauss (Strauss, 2003: 25)



Moreover, all nine categories are accompanied by a figure showing the concepts, indicators, and actions influencing the categories.

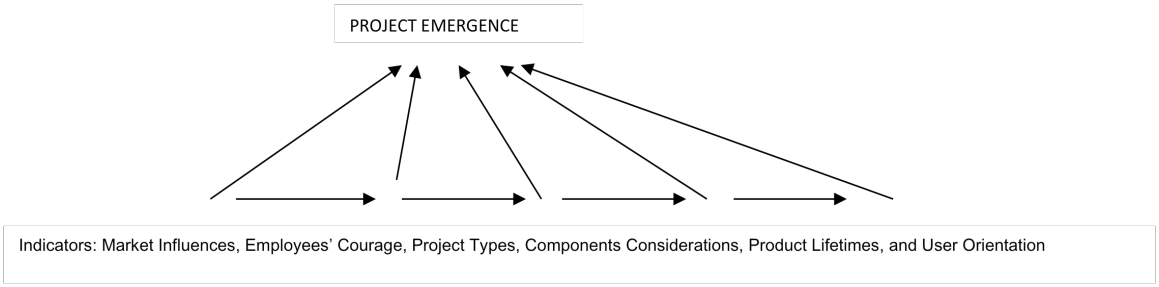
7.1 Project Emergence

The first category I develop is *project emergence*. This category identifies what elements influence how a project starts, and how a product is defined.

Six indicators influence project emergence. The six indicators are: market influences, employees' courage, project types, components considerations, product lifetimes, and user orientation.

The six indicators demonstrate what processes occur before the company is able to describe what projects and products to develop. The six indicators represent the elements that are important to discuss, and evaluate before developing a project idea into a project. By evaluating and discussing the six elements, employees enter into learning processes where they share information and knowledge before they decide what product idea to pursue.

Figure 9: The indicators for the category project emergence



Market Influences

The central *condition,* in my data, for starting a project, is the need for new information. Before starting up a project the development team evaluate the product portfolio to see if changes to existing products can produce cheaper new products with improved qualities.

For the management and development department both a technical, and a market motive lies behind development of new products. A technical motive brings the company forward by updating existing products to market standard, and a market motive drives innovation projects by focusing on producing sellable products.

New information results from *interactions* between the different company representatives, and external sources. For the management and the development department the *strategy* is to join with representatives from service, market, and production to collect new information from sellers, users, technological developments, components suppliers, industrial fair, and industry developments. An industrial fair represents an opportunity for a company to present, and display new products for their customers and the company's distribution network. An industrial fair also puts pressure on the company's innovation pace.

When employees get new information of any kind, they are able to give input that can result in new projects ideas. Moreover, the new information gives an opportunity to optimize technology, to deal with price competition, to add new components, or to participate in industrial fairs with new products.

Project ideas also come from considering damage reduction, and product improvement to ease certification of machines. A customer request can also initiate a new project, which can happen when a customer sees a competitor having a specific machine with features the customer wants the company to develop.

The *consequences* of implementing new ideas are either a prolonged life for existing products, or introduction of a new product in the market.

Employee Courage

If employees want to influence what ideas should become projects, they need to have courage. Moreover, I found that to start a new project, or restore a project on hold, employees' need courage to produce convincing arguments in favour of the project.

Furthermore, the studied company had adopted the Stage-Gate model to structure how they run their projects. In the Stage-Gate Model gatekeepers decide whether to pass a project from one phase to another based on logical business decisions. Hence, the gatekeepers determine whether a project should proceed, or not. Since the managers are gatekeepers, employees need to convince the managers about a project idea. Moreover, convincing arguments in favour of a project reduce a strong managerial involvement in the details of a project.

Employees' show courage when they seek to persuade the management by presenting convincing, and apparently neutral arguments in favour of a project. From the management perspective, the employees' arguments will only be convincing if presented by someone the management trust.

Project Types

I found that different project types yield different kinds of output. *Consequently*, project ideas are categorized into project types to identify the output the project will deliver.

The *strategy* behind the different project types involves not only output, but also what type of collaboration will take place. The project types can be technology projects, development projects, research projects, international projects, or long-term support projects. Technology projects focus on providing new technology, and the output from technology projects will supply a spin off to other projects. Development projects are strategic and supply a particular technological piece to an existing product. Research projects provide opportunity for slicing out technology in pieces in order to supply a broad number of the welding machines with the new technology, and add it to customer segments to get volume in production.

Long-term support projects provide core elements in machines, such as power supply and machine steering. In international projects it is more important what phase they are in rather than what output they produce, because in international projects it is necessary to know at what stage in the project development process the company's contribution is needed.

The collaborating partners in technology, and development projects are suppliers. But, when the company chooses to be an OEM (Original Equipment Manufacturer) the

company itself becomes a supplier of technology. As an OEM the company gets access to new knowledge, and technology from the company they collaborate with.

In research projects the collaborating parents are research institutions, or universities, which gives the company access to the forefront of technological developments.

Components Combination

A *consideration* at the start-up of a project is how to combine machine components. When projects start by recycling output from earlier projects using standard components, or by combining components from old machines with new components, the development participants are able to develop new packages of machine types with different dimensions and materials for specific customer groups.

The use of existing elements in a new product provides an opportunity to harvest technology, and knowledge since the elements need to be implemented, and to function in a new way. From a market perspective, the development managers focus on combining components to reuse technology from projects, and update existing market versions of products in a cost-effective way. *Consequently*, the spectrum of available components affects the product development.

However, if a constriction problem occurs during the development process where the intended components to be used in a machine does not fit, this requires a search for specific components. The latter leads to collaboration with external suppliers, to find the solution to the technical problem.

Changing products substantially, because machine components get outdated causes a technological shift in the produced machines, which create a new generation of products. Furthermore, a new generation of products enables the development department to construct generic machines independent of the welding process. A development such as this happens because the development team beforehand already has much of the machine parts, but to improve machine performance they need to search for new solutions, and more knowledge.

Product-Lifetimes

I found that the products lifetimes influence the product renewal rate. When the technology changes slowly, it influences the employees' drive to promote new innovative product ideas. Long product lifetimes cause slow product renewal rate, and give fewer new products in the market. In addition, few renewals on the component side, give products with well-known technology. From a learning perspective, slow product-lifetimes do not stimulate employees to come up with new ideas, and therefore they do not engage in discussions of new project ideas.

Nevertheless, the market developments influence the product lifetimes in the direction of shorter product lifetimes. With shorter product-lifetimes, the need for new products increases, and the innovation pace needs to increase. However, a shortening of product lifetimes, and upsurge in innovation pace add to the vulnerability of the product development process.

Increase in vulnerability relates to challenges of having to produce a product, which has market success, and at the same time is targeted for particular users. The company cannot afford to fail with their products in the market. The strategy to deal with shorter product lifetimes, and to avoid product vulnerability, is to hit "the bulls-eye" with products. In order to avoid loss of resources due to market failure, the development department manager focuses on ensuring payoff on long-term products, called flagship products.

A flagship product sells in large quantum, and give a steady income over time. Having a flagship product reduces the product development vulnerability. For a while, a flagship product gives the necessary economic freedom to develop new products. Nevertheless, over time, a flagship product becomes a standard product, the novelty wears off, and the incomes diminish, which in turn requires new flagship products.

User Orientation

My findings show that a central *condition* for reaching the market with the right project ideas is to emphasis user input. *Consequently*, new projects need to include user perspectives.

The *strategy* is to ensure that the development group, and the production employees include user input to produce a qualitative good product with the right performance. To achieve this the employees need to use information from the right user panel.

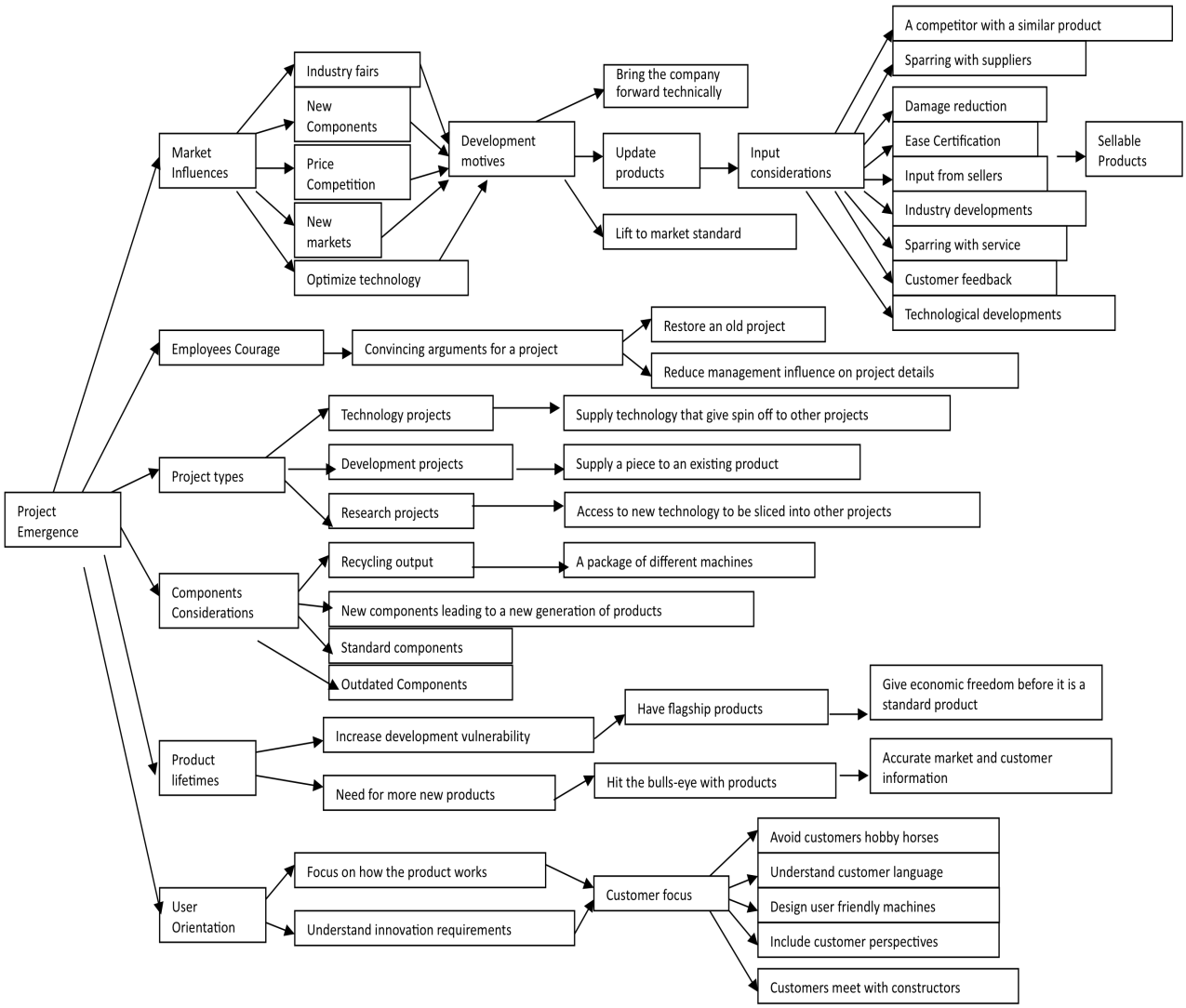
In order for developers to understand how users' wishes will influence the innovation requirements, users meet with constructors. The *strategy* is to feed knowledge of user patterns into the development department.

Nevertheless, it is necessary to finalize the user's wishes before entering construction. To get knowledge of user patterns into the development process, a manager in the development department suggested merging the Integrated Product Development Model with elements from the Stage-Gate Model. This was based on the manager's previous positive experiences with the Stage-Gate Model form another company. Moreover, the integration of the two development models changes how to do product development by orienting the product development towards the users.

However, to avoid development of machines for limited user groups, and at the same time considering users' wishes, requires the development team to understand customers' language.

Conditions for Project Emergence

Figure 10: A summary of the category project emergence

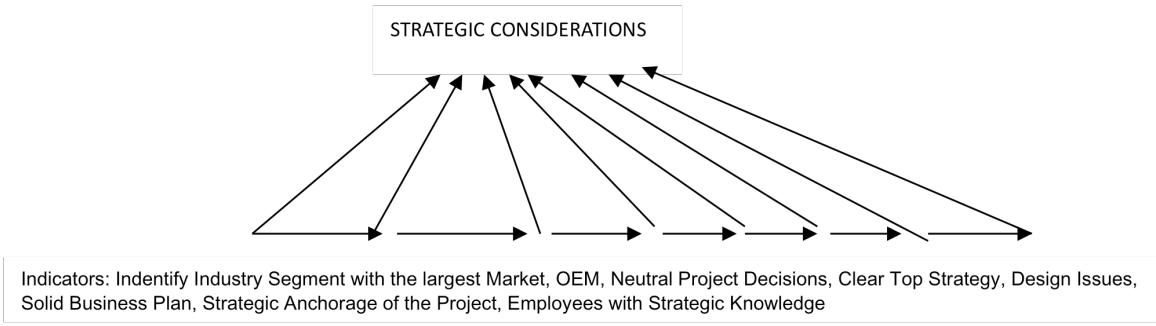


7.2 Strategic Considerations

The next category I develop is *strategic considerations*. The category "strategic considerations" identifies those strategic discussions, which influence what product ideas become projects.

Eight indicators define the category "strategic considerations". The eight indicators are: Identify the Industry Segment with the Largest Market, Original Equipment Manufacturer (OEM), Neutral Project Decisions, Clear Top Strategy, Design Issues, Solid Business Plan, Strategic Anchorage of the Project, and Employees' with Strategic Knowledge.

Figure 11: The indicators for the category strategic considerations



Identify the Industry Segment with the Largest Market

Strategic plans orientate the development process according to market segments by making strategic considerations. A strategic plan shows in what direction the company wants to go, by identifying the industry segment with the largest potential market. A project description can cover the next 2 – 3 years, and is related to the overall strategic plan. A strategic plan looks at both the development, and the qualification perspective in the company. The development manager can focus on either to produce for a broad spectrum of customers, or to be a specialist supplier.

A strategic plan contains information about the company's development direction based on the technology mastered in the development department and in the production department. The strategic plan displays what industrial segments the company aims to be leading in, how the company wants to be in front, how far in front, how well the company performs in relation to competitors, and what technology to use in machines.

In order to decide what market segments the company should aim for, the management needs to decide if they want a competitive edge, or only want to increase their sale. This choice decides whether the company wants to be lagging behind technologically by adopting and adapting known technology to their products, or to be in

front technologically by adopting and developing new technology for their products. The quality of the strategic considerations influences the company's capacity to run projects.

OEM

A *strategic* decision taken by the top manager is to be an Original Equipment Manufacturer (OEM). Being an OEM means to develop specific customer products in close collaboration with another producer.

In OEM collaborations, the company supplies parts to producers of other machines. The machines using the supplied parts are not welding machines. Since, the company only supply integrated parts, the final product is marketed and sold under another label.

Being an OEM gives access to new knowledge, and new technology. Moreover, as an OEM, the company gets their' parts marketed, and sold without having to invest in sale and marketing activities.

The *consequences* of being an OEM is that the company is not allowed to use their technological contributions as part of their own products, nor in marketing of their products.

Neutral Project Decisions

I found that an important *condition* before a project can start is that employees participating in the development of a new project need to convince the management. To convince the managers about a project, managers must receive non-biased information about the project. A spreadsheet is used to present information to managers in non-biased way, and to communicate the business in the project to the managerial gatekeepers.

Consequently, the project information emerges as non-biased, and management view their decisions taken by looking at the spreadsheet, as neutral project decisions. Moreover, to ensure that the managerial gatekeepers do not stop a project, the project groups' members must include employees whom the managerial representatives trust.

Clear Top Strategy

A clear top *strategy* defines what products to develop starting with a hypothesis relating to project ideas, and by comparing these ideas with the company's product portfolio. A strategy group consisting of all department managers defines the top strategy.

A clear top *strategy* defines whether a project idea is a good project based on the documents describing the idea, and the quality in these decision documents. If the project idea complies with the requirements in the documents, resources will be released to the project, and the project can start.

Design Issues

The central *condition,* regarding the design of the machines, is to provide the users with a user-friendly machine interface. Moreover, users are not interested in knowing where the technology is placed in the machine, since their concern is how the machine works. Hence, the *strategy* in design is to focus on the exterior of the machines. *Consequently*, to identify the requirements necessary to design user-friendly machines, users must be involved in many of the development phases.

A Solid Business Plan

A business plan documents how to collect information, what certainties, and uncertainties there are in relation to the project, and what competitors have done.

My findings reveal how a solid business plan operates on two levels. The first level considers aspects such as identification, and implementation of new technology in products. The second level of a business plan considers the potential profit to be gained from the product. These aspects are linked tightly together, and therefore whether a business plan deals with issues relating to construction, or issues relating to business, can be difficult to distinguish.

For each project, the respective business plan describes what market segments the machines need to aim for to earn money. However, in terms of setting up a budget for a project, budgets are normally based on long-term planning. An extra demand to a budget is the requirements coming from stockholders since the company is a publicly quoted company. Stockholders want high value for their stocks and put extra pressure to the degree of surplus from projects . Therefore, a budget needs to consider two financial aspects relating to the overall economy in the company: what market segment will give largest revenue, and whether or not the selected market will raise the company's share price.

As part of the business analysis considerations, checking what competitors have done requires knowledge of the industry. In the studied company, mainly the managing director possesses thorough knowledge about the welding industry.

The information in the business plan needs to be correct to ensure production of the right machine(s) for the right market(s). A business plan for a project covers 2 to 3 years.

The business plan is updated after each phase shift in the development model with a new set of key figure to control the development of the project, and to ensure that the product follows the requirements in the business plan. Some of the key figures defined in the business plan such as contribution rate, and present value are updated and measured until completion of a project. However, when considering the budget in

projects it is necessary to evaluate whether to produce products that will give a competitive edge, or to focus on products that will purely will give an economical growth. Hence, budgetary considerations may cause a project to shrink, or they can resume a project that originally was thrown away.

Around, 15% of the total project resources are invested in producing a business plan, and to get a project accepted. *Consequently*, the quality of the information reported in the business plan will influence whether products achieve payoff and hit right in the market.

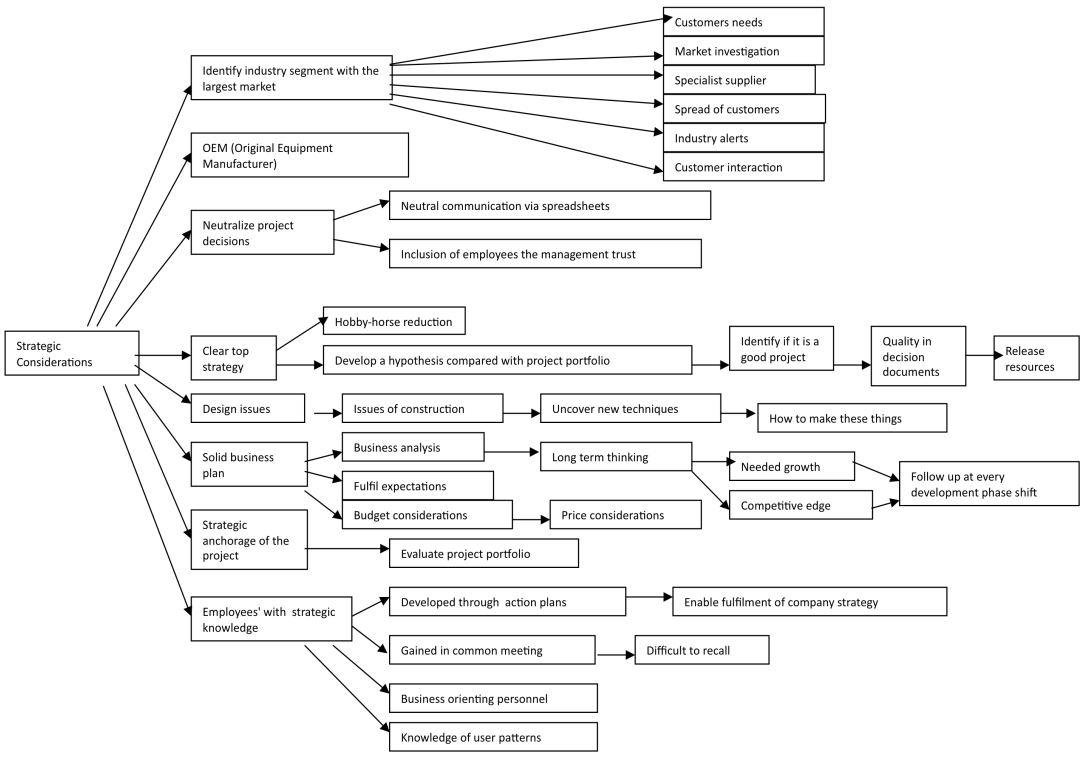
Employees with Strategic Knowledge

A *condition* regarding employees' contribution to product development is to consider how employees most successfully can gain strategic knowledge. In order for employees to gain strategic knowledge, it is not enough to give information about the company strategy in a common meeting, because then the strategic information will be difficult to recall.

The *strategy* is to develop action plans. Primarily, action plans are made for production and logistics, to explain for their employees how to carry out their tasks. *Consequently,* action plans describe what actions to take in order to achieve tasks, and once the employees' know how to do their tasks, they are able to fulfil the company's strategy.

Conditions for Strategic Considerations

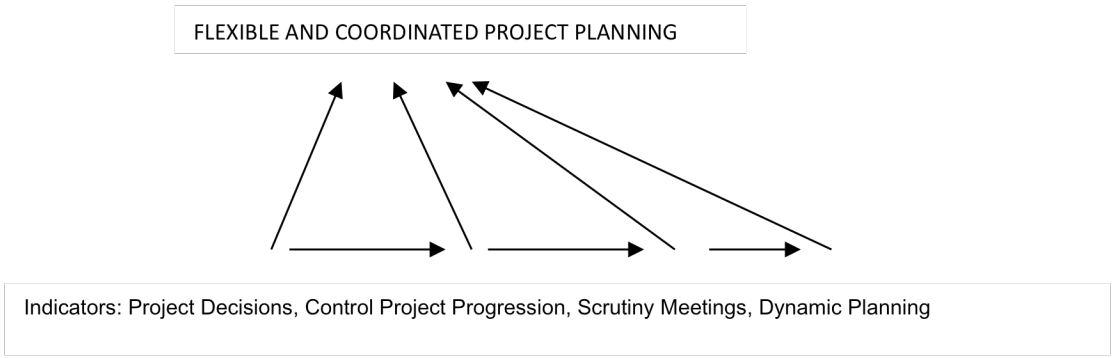
Figure 12: A summary of the category strategic considerations.



7.3 Flexible and Coordinated Project Planning

The category *flexible and coordinated project planning* identifies what elements influence the planning of projects. Four indicators influence flexible and coordinated project planning. The four indicators are: project decisions, scrutiny, dynamic planning, governing, and control project progression.

Figure 13: The indicators for the category flexible and coordinated project planning



Project Decisions

The *conditions* for projects I found, reveal that project control requires the participants in the development project are able to make the right decisions. These decisions must be taken by those qualified to do so, and who have the necessary authority.

The management group take approval decisions at each phase in the development model. These decisions are based on calculating the product lifetime, expected sales, and costs. Costs are optimized to increase earning power, to produce products at a lower cost, and by distributing costs by cooperating with suppliers.

The product costs is found by calculating the price on every module in a machine, and the project cost price is found by calculating the price of every project activity. The accumulated cost is equal the sum of the product and the project costs. Hence, the accumulated cost price represents the cost of both making, and running the project.

Control Project Progression

My research identifies how the company sought input on how to get control over the product development process. The *strategy* is to apply the Stage-Gate Model. The

choice to adopt the Stage-Gate Model is based on a suggestion from one of the project manager's. He has previously worked with this model in another company, and based on his suggestion, representatives from the development department participated in a seminar with Professor Robert G. Cooper in order to learn more about the Stage-Gate model. Professor Cooper is the originator of the Stage-Gate model. He emphasises in his Stage-Gate Model that companies "need to do their homework". By homework, Robert G. Cooper means that the companies need to identify who their users are, and to use at least 15% of the project expenses early in the product development process to identify profitable project ideas.

Furthermore, I found that the participants in project development projects emphasis that the company size, and extent of delegation of project responsibility affect how much overview, and control there is in the product development process. Moreover, the participants see the company size, with approx 400 employees, as a size that enables product development overview. For them a flexible and coordinate project planning means reduction of those factors influencing negatively on the project progression or project results.

Scrutiny

The Stage-Gate Model advocates regular scrutiny of the project in the development group together with representatives from production, planning, and logistics. When holding a scrutiny in a gate meeting the development group shall not introduce any new changes. The purpose of the gate meeting is to decide, using the information discussed in the meeting, whether a project shall proceed to the next stage or not.

The studied company arranges scrutinies, according to my investigation, to identify the challenges in a project. Two obligatory scrutinies are held before a gate meeting, and during the gate meeting. Finally, scrutinies that are more informal are held by those involved in the development of the product, based on initiative from the project managers. These informal scrutiny meetings have discussions that are more open.

Scrutiny groups are appointed at each project phase, and the scrutiny groups evaluate the product based on a checklist at each stage in the development model. The checklist identifies what is relevant to do, whether it has been done, or whether a task is transferred to someone else, and why. Competent personnel evaluate the content of a project using the checklist, and make a report. *Consequently*, management approves reviews, and evaluates the project in the gate meetings.

To prevent, too much meddling from the management in the details of the development project, issues relating to construction are not discussed in a scrutiny meeting. The management will not intervene in the construction of the product, and the

management does not take a stand to content. However, the managements identifies if the project represents good business, and they can influence if resources are going to be releases to the project. Furthermore, the gate meeting locks the product development wishes, coming from either developer any of the department representatives or users, to prevent further amendments to a product. After each gate meeting, the requirement specification becomes increasingly restricted.

Consequently, scrutiny meetings decides whether a machine has been sufficiently tested, and if a project shall proceed or be stopped. When scrutiny meetings are documented, it is easier to settle disputes concerning project decisions.

Dynamic Planning

Conditions such as change of project manager, limitations in resources, reorganizations causing transferral of tasks, removal of personnel caused by downsizing, transferral of task to departments with limited resources, and changes in production are project factors contributing to major changes in a project.

Furthermore, reorganizations of production introduce logistical challenges. These logistical challenges require employees' with updated knowledge capable to handle and keep-up production despite any changes made to how their work is organized. Reorganizations also place stronger emphasis on having qualified personnel in production familiar with the production processes.

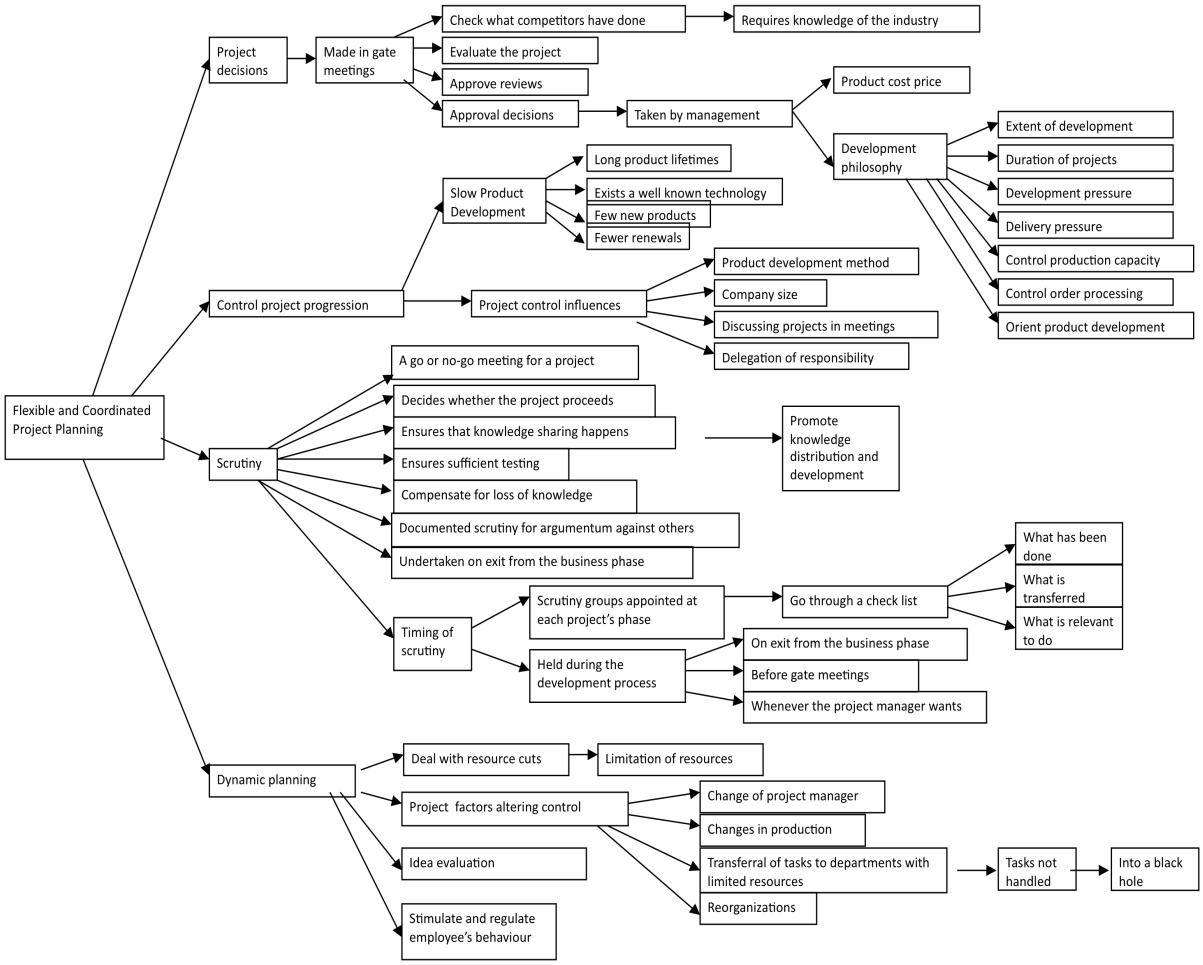
I found that by ensuring a dynamic planning, the challenges related to running a project could be diminished. Dynamic planning helps to control project progressions, and to deal with resource cuts. Furthermore, dynamic planning depends on being able to control the identified altering project factors.

Transferring tasks to another department causes them to disappear into a black hole. Tasks ending in the black hole are no ones responsibility, and they are not dealt with.

Reorganizations push things downward in the organization, and create a need for new routines and ICT (Information and Communication Technology) systems. To make the production as efficient as possible requires the company to control production, and to optimize production using integrated software system solutions. With the use of software tools such as MES (Manufacturing Execution System) for production and ERP (Enterprise Resource Planning) for all facets of the business, the connectivity and the visibility maximize across the company. The use of software packages makes production more transparent, and allows improvement of the coordination between activities in the development process.

Conditions for Flexible and Coordinated Project Planning

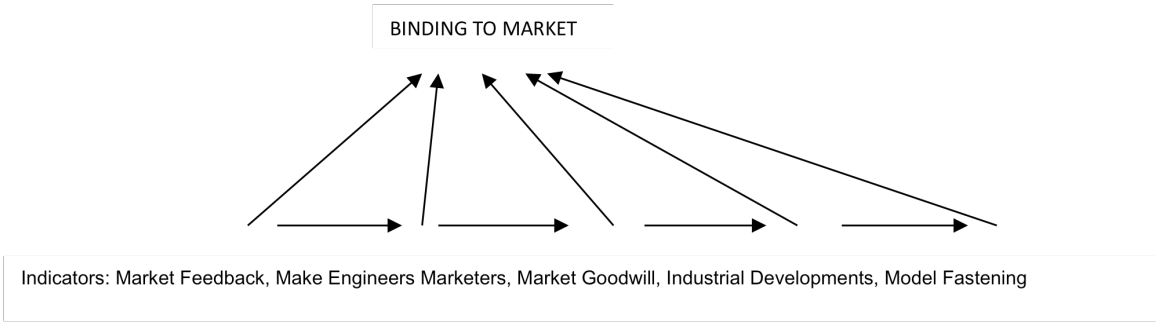
Figure 14: A summary of the category flexible and coordinate project planning.



7.4 Binding to Market

The category *binding to market* influences how projects are affected by market considerations. Five indicators influence market binding. The five indicators are: market feedback, making engineers marketers, market goodwill, industrial developments, and model fastening.

Figure 15: The indicators for the category binding to market



Market Feedback

According to my findings, the product development process elapses through three main development phases; the pilot phase, the production phase, and the guarantee phase. In each of these phases, the project manager follows up the business plan, and he follows up on the business plan once again after the project has finished.

The Stage-Gate model represents a change in the development department by advocating a stronger market focus during the development process. A market focus means going from attention on user features to attention on user benefits during the development process. A stronger market focus results from feeding information about the use of the products into the project group via the project manager. Subsequently, the product specification shrinks to a more concise description.

The *strategy* is to achieve better and more competitive products by focusing more on the market at the beginning of a project, and at the end of a project. *Consequently*, market orienting the development process makes people involved in development more responsible for earning money. Further, it requires the project manager to be market oriented at the beginning and end of projects. He is the one who is responsible for ensuring that the project becomes a success by fulfilling the users requirements, and by handling product reclamations.

The flipside of a stronger market focus is an increase in development vulnerability in terms of commercial success since products are more targeted to particular users.

Further, there is an increase in the requirements to the project manager. He has to follow how the sale of the product develops in relation to the business plan.

However, when projects have a strong technological focus, they may fail to meet the market's expectations. Under such circumstances the product specification documents help to settle disagreement between the marketing and development department. Product specifications enable the development department to backtrack and use the specifications to identify what was agreed upon in relation to the product, and how the product should work. Furthermore, documenting every aspect of the product during the development process helps to avoid contra arguments and disagreements about the product from marketing.

Making Engineers Marketer

I found that the engineers are unfamiliar with user requirements, and with the different uses of welding machines. Hence, the *strategy* is to make the engineers more market oriented by ensuring that the engineers consider users requests and to make the development projects user oriented.

When the development department engineers lack user knowledge, they need to communicate with users to understand user's needs, otherwise the engineers generate product features rather than product benefits. The users are not interested in fancy features, but are concerned with how the use of the product helps to solve their work tasks. A development process driven by technology will emphasize requirement specifications. Emphasizing technology in the requirement specification leads to a product development dominated by development engineers, and a technology oriented project group without much concern for the users.

Consequently, by making the engineers more attentive to and involved with the users, the engineers become marketers because they get more concerned about the market through a stronger emphasis on user needs and demands.

Market Goodwill

I found that the feedback on products from the different market sources is considered both objective and subjective. Objective feedback relates to technological issues, while subjective feedback are related to individuals' preferences. Objective feedback can be related to solder and to flux development. Subjective feedback can be related to user preferences on how to operate a machine. Both objective and subject inputs come from dealers, customers, suppliers, welder-gas producers, user, customers, product development partnerships, and competitors. Failure to handle this subjective and objective feedback correctly can violate partnerships, give project stoppage, or market

fiasco. How this market feedback is handled and interpreted is of essence to keep the market goodwill.

A first step towards market goodwill is to ensure that the products are requested and sold. This process starts with considering information collected by marketing. Marketing collects market information about what products to produce by approaching directors in subsidiaries, or by collecting information from dealers. During this process, the marketing department gets information on what products competitors are offering. The information collected by marketing does not contain information about the user's needs, only information about what products are sold by the competitors. The result is that the company never gets in front with their products technologically. *Consequently,* if competitor's products have faults, these faults are repeated when implementing the information supplied by marketing in the product development process.

Despite the efforts taken to market orient the product development process, to be able to sell products means to fight for market goodwill amongst customers and dealers. The development manager's strategy is to consider the market feedback before and during, product development.

The goodwill from single dealers depends on the product portfolio the company can offer. If the company has a limited product portfolio, they will not be able to offer the products the customers' request. Then the dealer turns to the products offered by competitors to find a product that can satisfy the customers' requirements. Subsequently, the dealer experiences a conflict of interest between the company's demand to a single dealer, and the need to supply customers with the products they ask for. *Consequently*, the single dealer becomes a disloyal dealer.

Industrial Developments

According to my empirical data, the market development within the industry affects the product development process. Within the welding industry, salary makes up a large proportion of the costs related to performing a welding task. Around 80% of the total cost of a welding task is labour costs. Furthermore, the development within welding is towards fewer well-educated welders. The result of less education is fewer welders who understand how to use a welding machine properly.

My findings reveal that there is an joint understanding between those who contribute to the welding industry on what good welding qualities are, on what welding machines shall look like, and what functions welding machine shall have. This agreement contributes to production of generic welding machines. A generic welding machine will be easy to operate, have a recognisable user-interface, and have a similar performance, independent of who produced the machines.

At the time of this study, heavy welding jobs move to Poland, Spain and Portugal, causing welding in Northern Europe to get more advanced and specialised. Northern Europe has a high degree of automation in welding, which poses additional requirements to production of welding machines. A new challenge for the welding industry is the rise of China as an industrial nation. The developments in China can cause further loss of welding jobs and new requirements to welding machine.

Consequently, with fewer well-educated welders' the welding machines need to be more efficient and easy to operate. These requirements result in welding machine more automated in use and with a similar user-interface. This development makes the exterior of welding machines look alike independent of the welding jobs they are developed for. Furthermore, such a market development requires product development employees with generic skills. When employees become generalists, anyone of them can be picked to do product development.

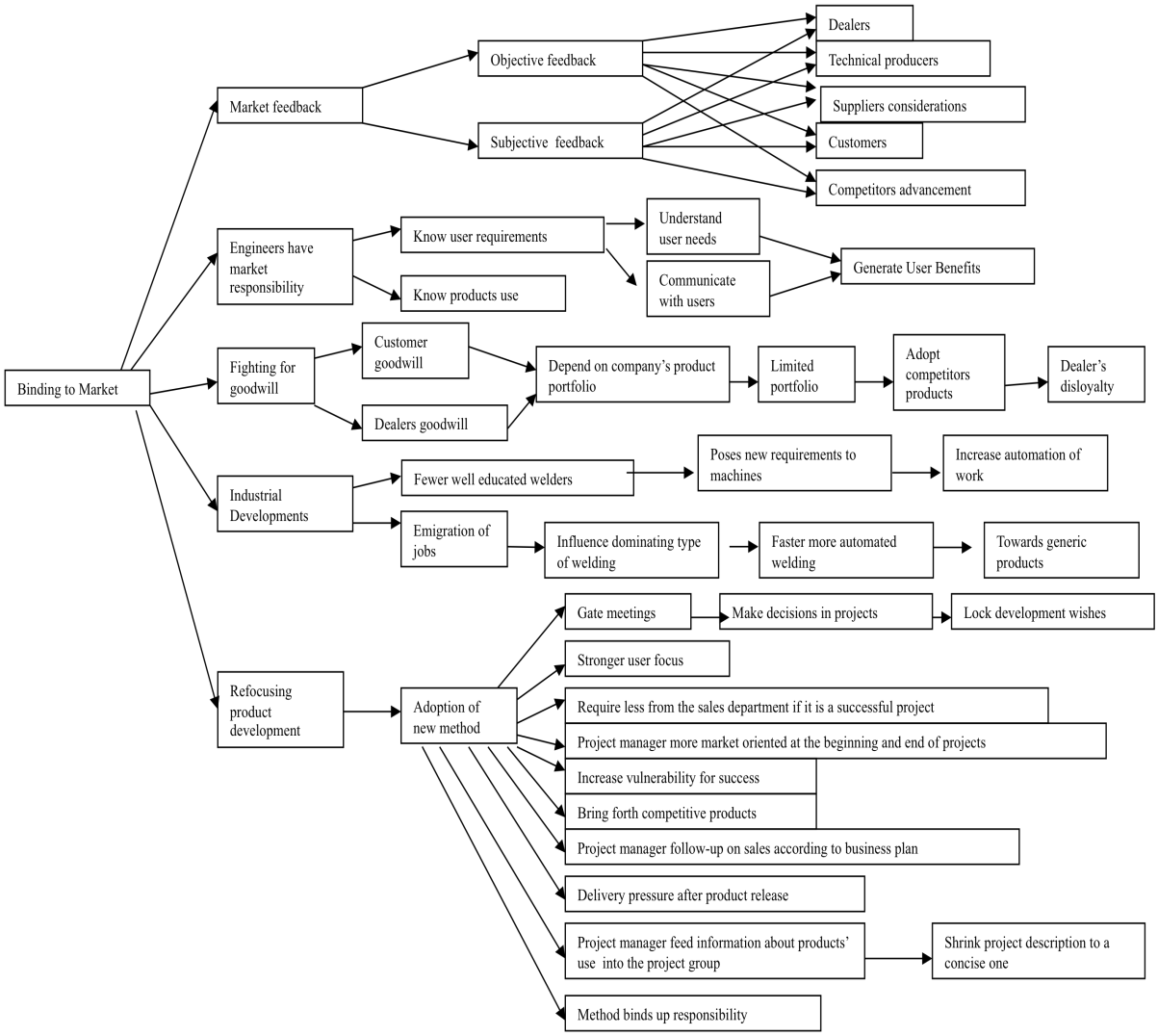
Re-localization of heavy welding jobs influence both what type of welding dominates the market, and the requirements to welding machines. *Consequently*, when machines are developed into automated solutions, they can replace as much as eight welding jobs, causing loss of sale of eight welding machines.

Model Fastening

I found in the data that the company wants a strong user focus in the early phases of a project, to bring forth competitive products. However, decisions in the project are tied up if there is a strong user focus in the early phases of a project. *Consequently*, the use of a product development model ties up the project, and the project decisions.

Conditions for Binding to Market

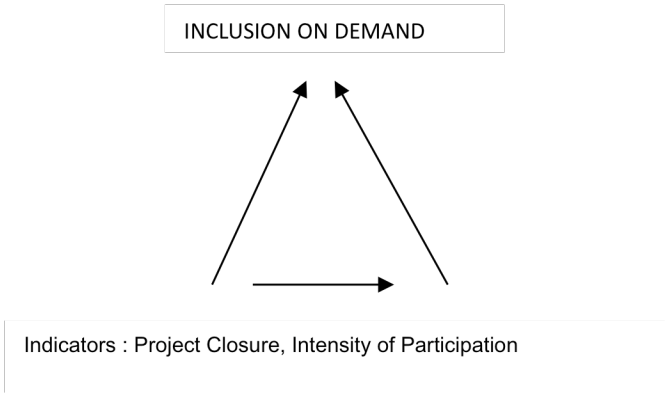
Figure 16: A summary of the category binding to market.



7.5 Inclusion on Demand

The category "inclusion on demand" identifies what elements influence when people are included in the development process to make their contribution. Two indicators influence inclusion on demand. The two indicators are: project closure, and intensity of inclusion.

Figure 17: The indicators for the category inclusion on demand



Project Closure

The category, inclusion on demand, describes what influences partaking in the product development project. Inclusion on demand follows a decision hierarchy going from top-management, to a product strategy group, and down to the project groups. Inclusion of personnel in the development project requires several considerations regarding their involvement. Inclusion of production workers in the development process reduces friction between development and production.

The cornerstone of the product development process in the studied company is the application of two product development models, the Integrated Product Development Model and the Stage-Gate Model (Andreasen and Hein, 1987; Cooper, 1991). One of the important elements of the Integrated Product Development Model is inclusion of marketing and production as early as possible in the product development process (Andreasen and Hein, 1987). The extent of inclusion and exclusion depend on the knowledge left in the remaining project group.

The product development group is responsible for the product until the end of the guarantee phase. However, it is important to include those who need to be part of a development project as early as possible, because after specification and when production has started, the decisions relating to a product is tied up, and it is too late for changes.

The personnel needed by the project manager, to contribute to the product development project, are included in a project on his demand. The project manager includes personnel in the development process when there is a need for them, and because they need to learn about the project.

Subsequently, two elements influencing involvement are diversification and project closure. Diversification in involvement happens by including personnel from different departments, and project closure happens by keeping personnel out of the development project. Despite running an integrated product development model, it is not given that all relevant personnel will be included in the development process. The project manager might miss or deliberately leave out personnel from the development process. Consequently, other functions or departments will approach the project manager and require to be invited into the project group. Therefore, when it comes to inclusion of different personnel from different departments, the degree and timing of inclusion varies.

However, inclusion on demand relates to who will be included when, and the main aim is to ensure that all relevant actors are included as early as possible in the development process. Therefore, when the project manager talks about issues relating to inclusion and exclusion in projects, he is talking about who will be included in the product development project and at what time. Furthermore, the project manager holds the reins during product development, and he decides how open or closed the product development process shall be.

Consequently, inclusion on demand affects product development. Inclusion gives access to new ideas resulting from involvement, and feedback. The project manager's attitude is that inclusion of employees in the project groups gives more work, but do not give more problems. Involvement in the development process reduces friction between development and production. Furthermore, inclusion happens on a need basis in regular project meetings with participation from production, logistics, purchase, and end-montage. To ensure input from sales and to evaluate if ideas are economically worth pursuing, sales representatives are part of all the development phases. To share experiences and knowledge the development team sits together and discuss. *Consequently*, involvement ensures that employees know what contribution they are expected to give to the product development process.

The challenge for the company is to deal with project closure. The category project closure is caused by lack of communication, and lack of exchange of experiences. Project development closure happens when the project group is isolated from other departments, other employees, and is unwilling to let others in on the development process.

When project closure happens, a discrepancy is created between those inside, and those outside the development process. Project closure creates a discrepancy between how far the product development process actually has reached, and how far the process is

perceived to have come by those who are excluded from the process. Project closure also creates a discrepancy between the results from the project, and what those outside the development process perceive the output from the project to be. *Consequently*, a mismatch occurs between the actual project progression and results, and the expected project progression and results. Moreover, project closure results from a lacking involvement, and violates the Integrated Product Development Model.

Furthermore, discrepancy occurs when, relevant employees are kept outside the product development process. Closure causes much manual steering and re-do in production when the production employees lack understanding of how to assemble the product before it reaches production.

Intensity of Participation

Membership in a project might vary according to project type. Therefore, completely new products might require more intense involvement of all potential contributors, while an upgrade of a project requires less involvement.

I found that a central *condition* for creating a more flexible integration of contributors to projects is to run projects in parallel to ensure inclusion of all needed functions. Employees from the purchase department, electronic department, montage department, logistics department, a production technical assistant (PTA), and the product manager all contribute in a project. Employees from the economy department are involved when working with new or supporting old, projects, due to follow-ups. Marketing and sales are included in the development process until project completion in order to present ideas for the project group and the economy in them. Production does not influence the development of products, but can express dissatisfaction relating to factors that influence production. Because employees in production represent views and knowledge relating to production, they are included early. Early inclusion of relevant employees from the production department provides support for the project all the way to production. Since, employees in production has knowledge about parts, their inclusion in the project group reduces friction between the development group and employees in production. Moreover, how to produce the product and the product part lists influences the construction of a product.

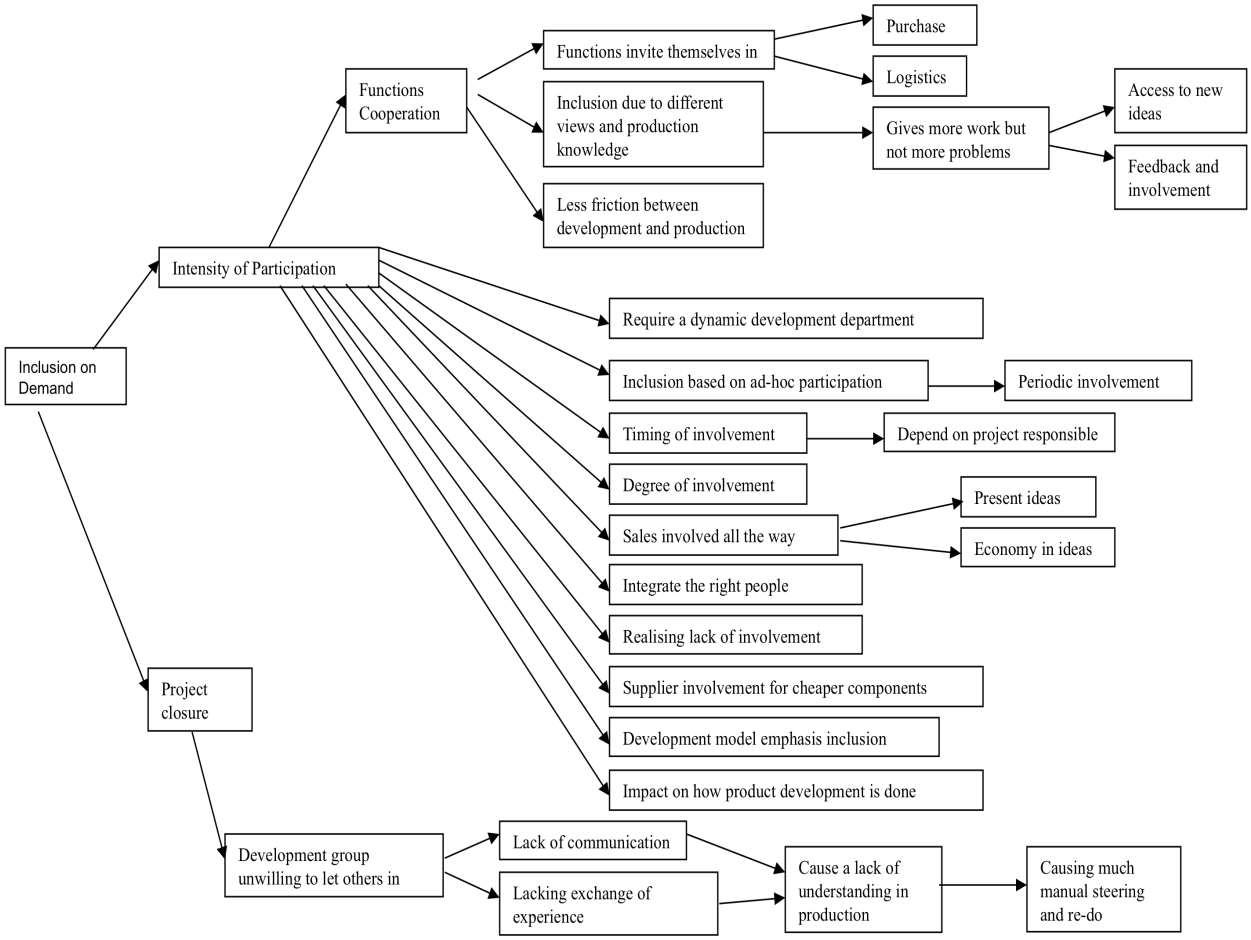
Participation by other departments varies in intensity. Inclusion of new functions in the development process requires a dynamic development department. When performing tasks or projects that require external knowledge, those groups possessing this knowledge will be included. Typically, serial production requires involvement of production and the development department.

Furthermore, when it comes to follow up projects due to reclamations, production needs to involve all departments including purchase and logistics.

The *strategy* is that those assigned to develop a machine are also included in finishing the machine. The project manager running the product development process invites the relevant contributors in on the process, and in some cases the contributors invite themselves in.

Conditions for Inclusion on demand

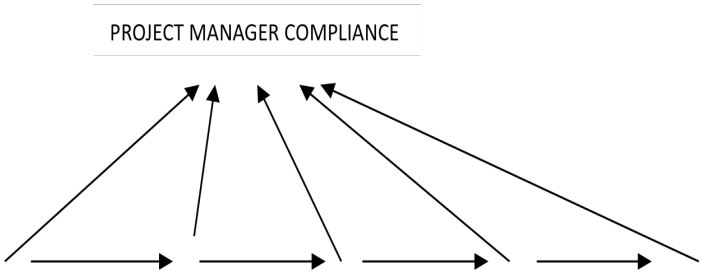
Figure 18: A summary of the category inclusion on demand



7.6 Project Manager Compliance

The category, *project manager compliance,* identifies what elements influence the requirements, and expectations to a project manager. Project manager compliance encompasses those factors shaping a project manger. Twenty indicators influence project manager compliance. The twenty indicators are: Early Involvement, Create Project Manager Generalist, Select Qualified Project Manager, Task Responsibility, Be a Project Manager should be Within a Person, Collect the Needed Knowledge, Inspire the Development Team, Include Knowledgeable Project Personnel, Make the Project a Success, Keep Time Schedules, Know the Constructors Perceptions of the Development Model, Deal with the Future, Ensure Project Personnel with Capacity, Avoid Construction Tasks, Build Networks, Previous Experience, Coordinate Projects, Assume Extra Responsibility, Focus on Earnings, and Run Projects until Completion.

Figure 19: The indicators for the category project manager compliance



Categories: Early Involvement, Create Project Manager Generalist, Select Qualified Project Manager, Task Responsibility, Be a Project Manager should be Within a Person, Collect the Needed Knowledge, Inspire the Development Team, Include Knowledgeable Project Personnel, Make the Project a Success, Keep Time Schedules, Know the Constructors Perceptions of the Development Model, Deal with the Future, Ensure Project Personnel with Capacity, Avoid Construction Tasks, Build Networks, Previous Experience, Coordinate Projects, Assume Extra Responsibility, Focus on Earnings, Run Projects until Completion

Early Involvement

I found in the data an emphasis on getting the project manager involved in the project as early as possible. The project manager needs to be involved early to be able to consider what the market is asking for, what variants the market asks for, and what corrections to implement in existing products. Without an early involvement of the project manager to take these considerations, the total project process takes longer time. Furthermore, involving the project manager early also ensures early involvement of sales representatives.

Consequently, the project manager must be included as early as possible.

Create Project Manager Generalist

I found that the project manager classifies the personnel's' knowledge through appraisals interviews to discover what the personnel know and what they need to know. The development department employees' build their competence by mapping their knowledge to projects. Moreover, development employees become generalists by participating in various projects, by changing tasks, by changing job assignments, and by attending courses.

The *strategy* is to ensure that the development department personnel are those who know most about user/customers machine requirements, and how to turn development staff into generalists. *Consequently*, making personnel generalists enables spread of knowledge by spreading people onto different project groups. Over time, this arrangement makes it possible to pick anyone from the development department to be a project manager.

Select Qualified Project Manager

I found that the technical director is the one who appoints qualified project managers. Being qualified as a project manager depends on experience, and that one has learned to keep a development process going.

The technical director ensures qualified project managers and the right resource distribution in projects, based on what he identifies will take to finish the project. A project manager shall be able to keep an overview of the whole product development process. This means he shall be able to read the future and act accordingly. He shall be able to keep time schedules, get the right personnel to do product development at the right time, and to finish the project.

An assessment of a project manager takes into account whether he makes the project a success or not. A project manager shall be able to identify the competences needed, and make sure the personnel involved has the capacity, and knowledge to do their job. A project manger also needs to have marketing, sales, and technological knowledge. A project manager shall inspire the personnel, and make them co-play.

Consequently, a project manager need to understand the requirements to qualifications when participating in external collaborations, as well as in projects with foreign and domestic research, and educational institutions. These collaborations require a closer look at in-house qualifications, and the project manager must identify if the collaborations require more in-house capacity or more in-house education.

Task Responsibility

Because the company adopted the Stage-Gate model, this has caused more responsibility and more administration for the project manager. Project manager is responsible for introducing new project tasks. The project manager can choose to delegate tasks. However, delegating project tasks also means giving up on project control. When the project manager delegates responsibility for project parts, he is also delegating the control of the project.

Due to resource limitations, projects get split into smaller project tasks, and the tasks are distributed to various projects. With smaller project units, some parts of a project can be finished on time, while other project parts get postphone.

Project tasks can also be split onto a subsidiary. Then subsidiaries supply elements or solve tasks related to specific development projects.

Be a Project Manager should be Within the Person

A project manager is not solely something a person can be educated to. Being a project manager should come from within a person.

Collect the Needed Knowledge

A project manager needs to be able to collect knowledge, and to know where to collect the necessary knowledge when needed. When a project manager needs expert knowledge, he can choose either to borrow resources inside the company, or to rely on an external expert. However, if the project manager chooses to get an outside expert, this expert needs to be able to communicate with the development group. If the outside expert is unable to communicate with the development group, the project manager can be forced to select a person inside the company that are better at communicating with the development group, despite the fact that this person might be less qualified. *Consequently*, even if people are qualified to do a job, if they are unable to cooperate with others, they are of no value in the development project.

Inspire the Development Team

A project manager needs to inspire the development team in order to make them work together as a team.

Include Knowledgeable Project Personnel

In my data, I encountered that, changes in key personnel causes discontinuity in projects. For example when transferring construction tasks to a project manager, this will lead to poor project management, because when the project manager is forced to do

construction tasks, he will have to balance between project management and practical problem solving.

Make the Project a Success

The ultimate measure of a good project manager is someone who is able to make the development project a success.

To make a project a success the project manager needs information about how products are used to convey this information to the project group, and make sure this is converted into a concise product description. With this approach, vulnerability increases in terms of commercial success. Therefore a follow up phase require the project manager to analyse how sales are going in relation to the business plan.

A project manager is vital for the success of a project. The project manager needs to make a flock of 20 to 30 people work together, and ensure they enter the project process at the right time.

Keep the Time Schedules and Deal with the Future

A project manager needs to keep time schedules, and to have project personnel with capacity and knowledge about marketing, sales, and technology concerning the products.

A project manager needs to have project overview, and be able to look into the future and take it in.

Know the Constructors Perceptions of the Development Model

A particular project manager challenge is to know how much the individual constructor perceives of the development model. The individual constructor's perception of the development model will affect the production development process regarding how easy or difficult it is for the constructor, to comply with the model's requirements.

Ensure Project Personnel with Capacity

During product development projects, the project manager has personnel responsibility for those working in his project group, including holding appraisals interviews.

Avoid Construction Tasks

For the project manager the adoption of the Stage-Gate model requires more focus on money and earnings, and less focus on construction tasks. Subsequently, being a project manager involves more administrative tasks. As the project manager role changes

there is less opportunities to do construction tasks, and more focus is placed on being a project manager.

Build Networks

A project manger needs to participate in industrial fairs to get new knowledge and new networks. The strategy is that an industrial fair gives the project manager an opportunity to extend his contact network and to gain new knowledge. When the project manager participates at an industrial fair, he gets a broad network of business managers, sellers, and customers. Besides, the Industrial fair represents a milestone where the company gets an opportunity to display for customers and for the distribution network their latest developments. Good marketing is defined by the marketing personnel as how many you know (your business network).

Previous Experience

People can have a project manager education, but it is equally important that they have previous experience from running projects.

Coordinate Projects and Assume Extra Responsibility

A project manager needs to coordinate projects and to be good at dynamic planning.
Additionally the project manager needs to be able to coordinate project progression with other internal departments, with customers, and be able to complete a project.

During product development the project manager assumes extra responsibility for the product development process, because of the requirements posed to him, and the pressure to make the project a success.

Focus on Earnings

When the product development orientates towards the market, the project manager must focus on the selected market segment when starting up a project, and when ending a project. A more market oriented approach, increases vulnerability in terms of commercial success, and requires the project manager to follow how the sale of the product develops in relation to the business plan.

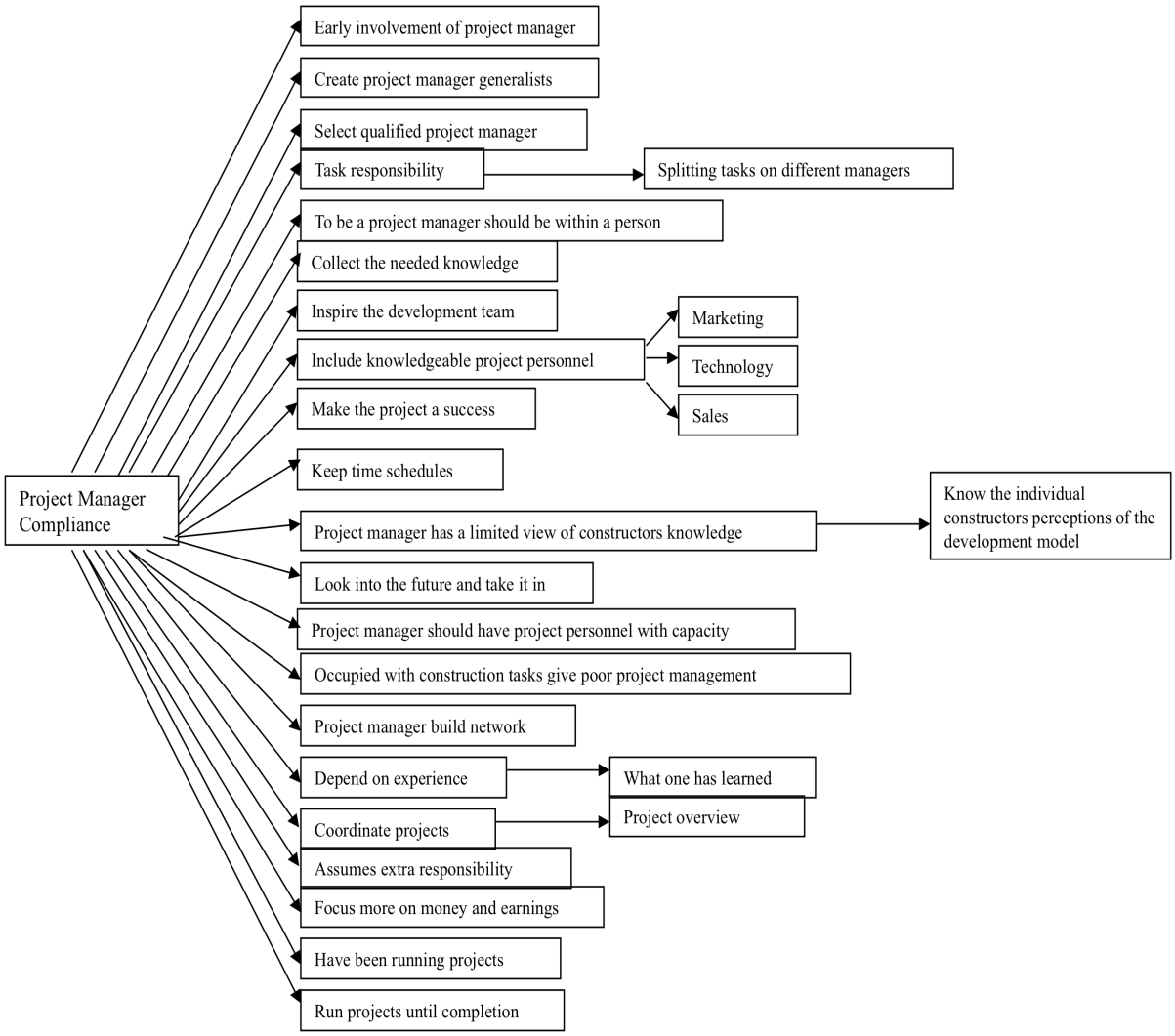
Run Projects until Completion

The project manager faces a challenge when introducing a new project structure, because some of the employees' see introduction to new tasks as insurmountable and will oppose it. Further challenges facing the project manager are the responsibility for feeding information about the use of products into the project group. This information causes the

specification to shrink to a more concise description. When a product specification shrinks this means omission and reduction of the possibilities for new variants, new projects, and new technology to emerge from the project.

Conditions for Project Manager Compliance

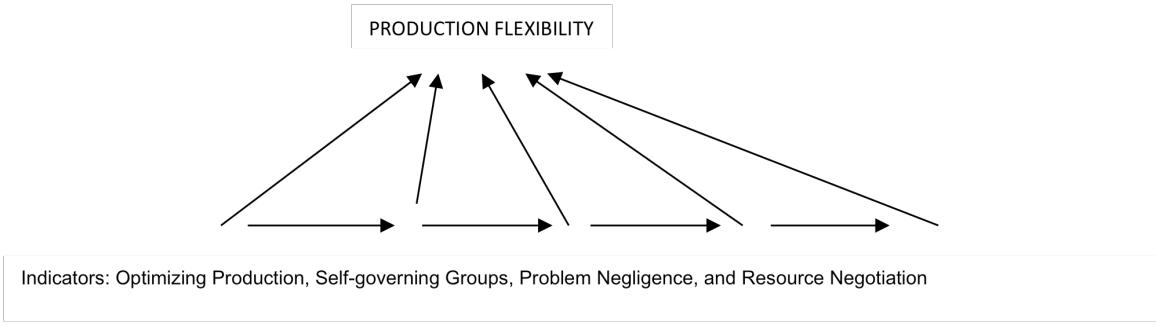
Figure 20: A summary of the category, project manager compliance.



7.7 Production Flexibility

The category *production flexibility* identifies what elements influence flexibility in production. Four indicators influence production flexibility. The four indicators are: optimizing production, problem negligence, self-governing project groups, and resource negotiation.

Figure 21: The indicators for the category, production flexibility



Optimizing Production

A central *condition*, I found, for running production as efficient as possible, is to ensure flexibility in production. Efficiency in production is achieved by using standard modules from the serial production, and by recycling output from earlier projects. Such an approach gives new machine types.

The *strategy* for achieving flexibility in production is to organize production into serial production. By using a serial production, modules are produced efficiently. However, to allow adjustment of products to fit user requirement, and at the same time allow short notice delivery, a part of production is organized into order production. In this way, the company combines serial production with order production. A combination of serial and order production is achieved by using standard elements in the assembly of the welding machine, and then supplying a customer specific exterior on the machine. In this way, the company can customize their welding machines to customers' requests. The use of standard elements gives production the possibility to produce machines with different dimensions, and materials for specific customer groups independent of what welding process the customers are using the machines for. *Consequently*, the use of standard modules gives an opportunity for flexibility in production.

User-friendly flexibility means adjusting products to the individual customers' requests typically by changing the exterior. The company can mass-customize their products, by only changing the exterior of machines, as part of a serial production and using standard elements.

Mass-customization is possible to achieve in production by having a storage of machines parts in production to produce optimal serials of machines. Storage of parts, allows production of sub-modules, which can fit into machines developed for specific users. Being able to customize products according to user requirements, and have an efficient production is done when part of the machine is produced in serial production, and part of the machine is put together in an order production. This mass-customization allows faster and easier production of customer specific products, by using standard parts or parts from a standard machine. However, having an order production line can lead to production of too many purpose-built machines aimed at specific users. To compensate this batch production is used. In batch production, machines are purpose built, but not customer specific.

Contrary, batch production, allows reuse of technology in projects, and provides an update of existing market versions of products. *Consequently*, building a welding machine using batch production means to be able to apply standard elements in a rational and smart way. *Consequently*, the vital parts in the machine are similar to any other machine, and the customer specific parts are fewer and easier to modify.

Self-governing Groups

Changes in production affect the end-montage, and requires flexibility. Once a product has reached maturity by fulfilling all the requirements to the product, the development department makes a parts list. The company's computer system makes the part list for the product available for production employees.

Furthermore, to run production as efficient as possible it is necessary that production workers are flexible. Flexible workers can be placed anywhere they are needed in production. Moreover, to improve the flexibility of production workers the company implements self-governing groups. By implementing self-governing groups, the company gets flexible workers and can compensate for having fewer employees in production.

However, to run the production process as smoothly as possible the product components must be available for sampling by the self-governing groups. The downside of such reorganizations is that it creates surplus of employees. Re-organization of production makes the production foreman more responsible for production and makes the production assistants redundant.

Consequently, the use of self-governed rotating groups gives a more efficient production, and gives workers with broader experience.

Problem Negligence

My investigation shows that the average product development time in the studied company was approx 2 and a ½ year (in 2001), but the aim was to reduce the time to 1 year. Hindrances to a faster product development process are delays caused by neglecting, or underestimating technological challenges, in particular underestimating challenges with new technology. Furthermore, reclamations disrupt work because they are concurrent with the business plan for the next project. These factors points towards a lack of attention and a neglect of central development problems.

Delays occur either because of changes in construction, or lack of testing of machine expectations such as ignites qualities' or welding qualities. In addition, delays can occur due to cutbacks, poor economy, under-allocation of resources, or lack of time. Suspension of product development causes pressure on the development process.

Consequently, delaying time to production, delay time to market, cause price drop, and loss of earnings.

Resource Negotiation

I found that a *condition* for reducing project delays' requires optimum resource distribution. To distribute the right resources to the right project groups at the right time requires authority to allocate resources, resource overview, and resource knowledge. With limited resources available, there is competition over the amount of resources, and those with authority will influence the outcome. In order to handle these conditions the management group grants resources, and the strategy group approves projects. Furthermore, resource re-distribution results from negotiating with the project managers responsible for other projects. Therefore, only a resource supply from other departments will yield a product.

In total, the development department uses 4% of the company's yearly turnover to develop projects, but the development department wants to increase it to 10%. Such a change requires better resource distribution between projects.

There are two ways in which resource distribution happens. The first is through negotiations between project managers, and the second is by synchronizing running projects.

Through a resource negotiation process between project managers, projects borrow resources from each other, and the result is a better resource distribution. Projects are synchronized to give an optimal resource distribution between projects. This happens by ensuring that new projects in need of resource are timed with those resources coming from finished projects. Furthermore, timing of resources enables the project groups to continue with their projects without having to wait for resources. Since there is no vacant

time between projects, the numbers of projects are regulated in order to be able to synchronize the development phases.

Organizing the work in production differently, does not necessarily yield any extra resources, but causes further strain on existing resources. Furthermore, draining resources from other projects can cause fighting over resources and suspending project completion. Moreover, loss of personnel and lack of economical resources cause resource reduction, resulting in either diminishing the scale of the project or stopping the project completely. Hence, optimal resource distribution requires correct resource allocation.

Manageable Variants

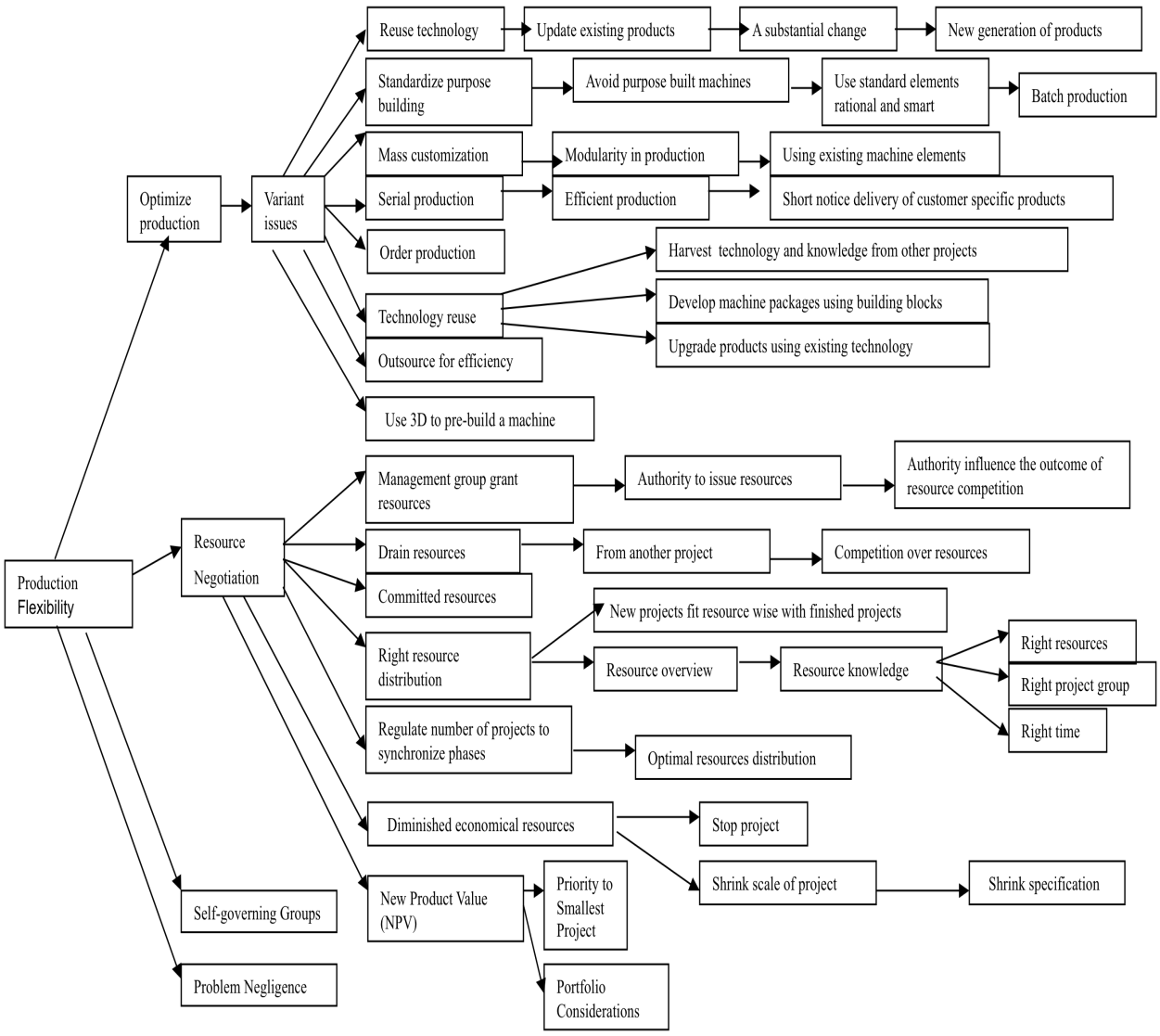
A new product can give many different variants as well as minor changes in existing products. New variants result from generating new products, or from amendments to existing products. Even if the number of variants decline during trial production, further reduction in number of product variants is necessary to get a manageable number. Getting a manageable number of product variants requires "drowning project puppies" (get rid of particular project favoured by some of the development participants), handling several projects running in parallel, and controlling the development processes.

Furthermore, the *strategy* is to handle all the variants that can emerge from the same project, and to ensure that they generate money. To further reduce the number of variants the company needs to consider both the sales figures for those machines that the new product substitutes, and the money made from the new product variants. Another approach is to use projects NPV (New Product Value) to prioritize projects and project resources. When two projects with the same NPV (New Product Value) compete for resources, the smallest project get priority after consulting the company's product portfolio. Because, small projects are faster and often easier to finish, they can more easily release resources for other projects.

The strategy is to keep a best fit between resources and deadlines by having a manageable number of product variants. Without a manageable number of product variants both employees' motivation and the available resources in a project will be affected negatively.

Conditions for Production Flexibility

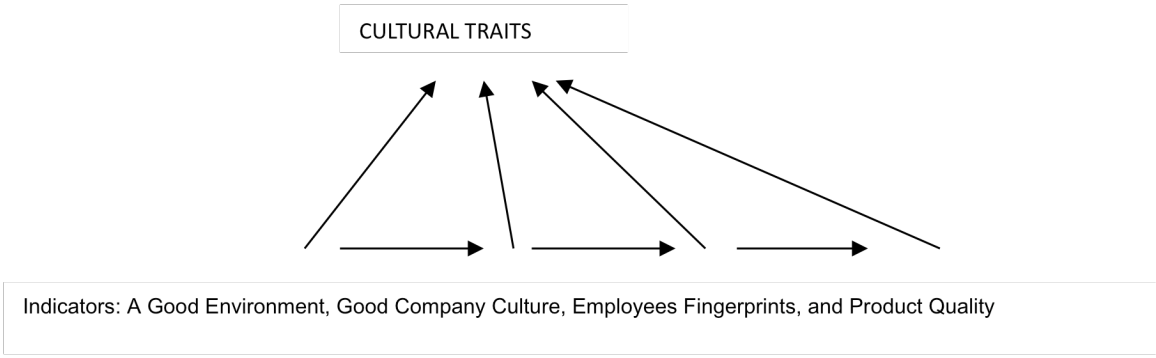
Figure 22: A summary of the category production flexibility.



7.8 Cultural Traits

The category, *cultural traits,* identifies what elements are seen as important for creating a good company culture. Four indicators influence cultural traits. The four indicators are: a good environment, a good company culture, employees' fingerprints, and product quality.

Figure 23: The indicators for the category cultural traits



A claim made about product development participation is that it can be seen as a role-play. When employees participating in the development process are playing different roles in the development process, they need to display different sets of skills and knowledge for each role. However, this role-play is seen as dilettantism. Seeing participation in product development as dilettantism requires a person to participate in a role-play, and to wear different hats during the development process depending on what task he is required to do as part of the development project. A dilettante means someone "who dabbles in a subject for enjoyment but without serious study" (Oxford Online Dictionary, 2007). Moreover, a dilettante acts without genuine interest in the studied subject.

The downside of the role-play during product development happens when a person only pretend in the project, and act not out of interest or knowledge, but rather because of previously role knowledge.

The available project resources will influence who gets a role in the product development project.

A Good Environment

A good working environment consists of a team of inspiring humans that can lift each other, and who has the knowledge required to perform the development process efficiently. In addition, organizing the product development teams into a cross discipline group with their own physical working space, contribute to efficiency in output to

projects. However, within certain subject areas the employees in the development department need to be kept separate from the rest of the development group, in order to develop expert knowledge within areas such as IT or electronics.

In a good working environment, employees' are able to raise their opinions and produce convincing arguments for a particular project or idea.

Good Company Culture

Building a good company culture is a co-play of many things. Facilities such as fitness studio, sports association, and an active employee union help in building a good company culture. The challenge is whether employees will use such facilities. To achieve a good culture in the company the projects need the right type of people. Consequently, the challenge is how to put together the right set of people and integrate them.

Employees Fingerprints

Fingerprints are identifiable changes/adjustments made to the product because of specific input from a product development participant.

When projects are developed, there are instances where the participants in the process can see their own fingerprints in the product. This is experienced as inspiring and satisfying for the employees.

Product Quality

Quality strongly influences the culture in the company. For the company quality in the product development process is equal to reliability.

The employees do not share the same picture of what the product will look like, and the project manager finds it challenging. The developers need to know what consequences the requirements will have on the products.

One challenge is to avoid having development engineers driving the development process towards development of "the perfect product". There is a conflict of interests here since management and sale push for new products, while the development personnel want to continue development and could keep on developing until eternity.

The strategy is to adjust the adopted product development model according to their quality insurance system. Furthermore, the product manager uses the quality insurance system to eliminate any discrepancies in products.

Furthermore, by using 3D tools it is easy to visualize what the products will look like. The use of 3D tools allows a prototype of the machine to be built beforehand, and with such a prototype errors are easier to identify, and easier to eliminate. Developing a prototype gives a good picture of what the product would look like, but at the same time, a prototype locks the product at an early stage.

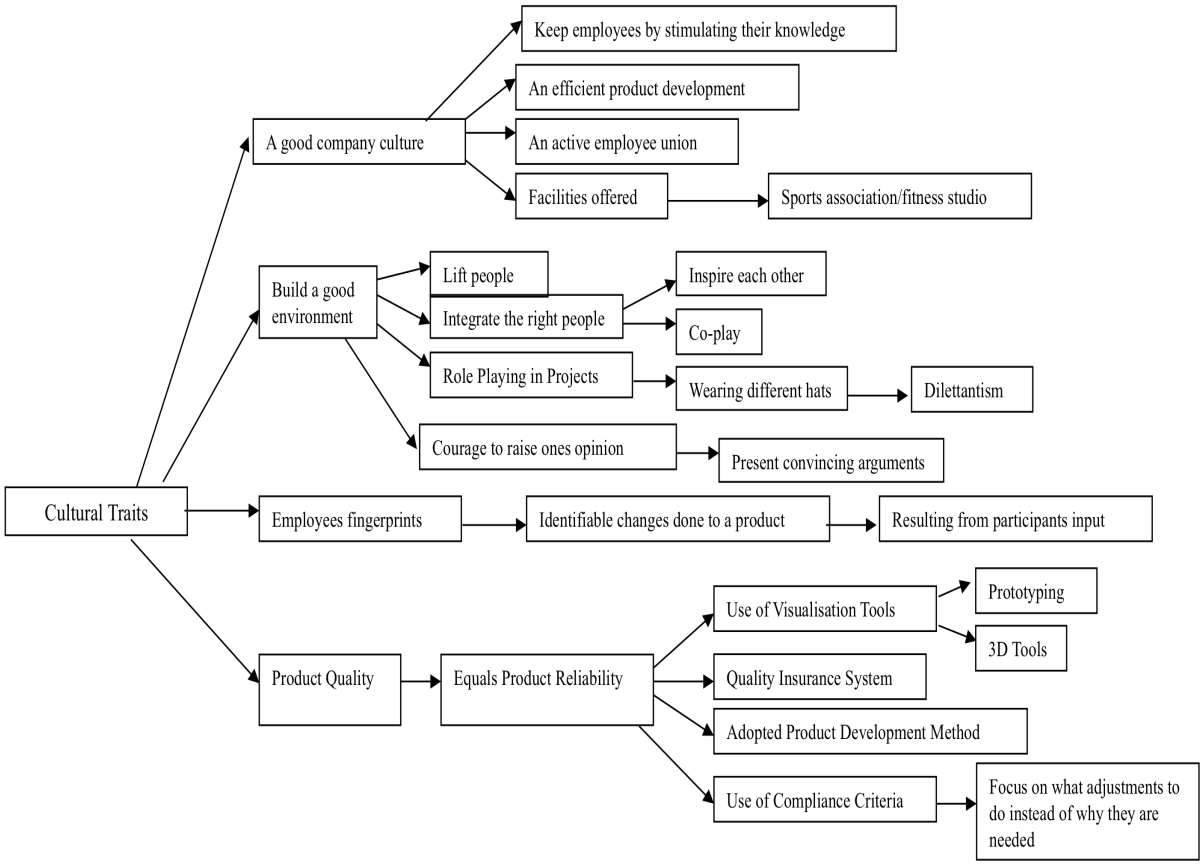
Compliance criteria define requirements to the product and to the developer. Product compliance criteria focus on what adjustments need implementation to develop a product, instead of focusing on why there is a need for the adjustments.

Such an adaption depends on dynamic planning, since continuous changes require coordination between projects.

Consequently, a good company culture reduces negative feedback, the amount of re-do and quarrelling related to finding those responsible for errors, and the need to identify potential scapegoats.

Conditions for Cultural Traits

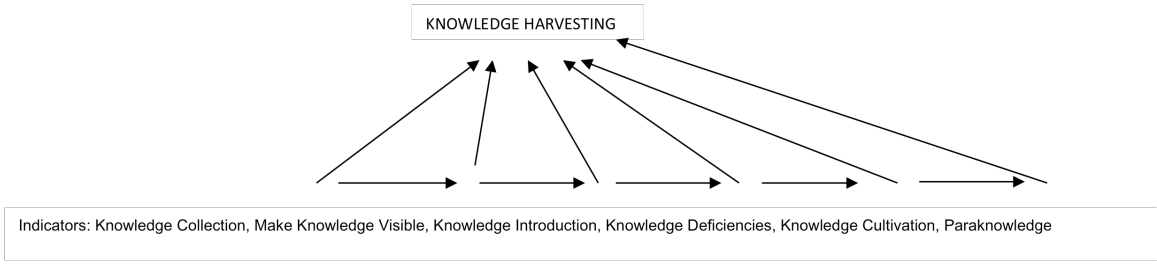
Figure 24: A summary of the category cultural traits.



7.9 Knowledge Harvesting

The category *knowledge harvesting* summarizes the elements influencing how knowledge is identified and distributed in the company. Six indicators influence knowledge harvesting. The six indicators are: Knowledge Collection, Make Knowledge Visible, Knowledge Introduction, Knowledge Deficiencies, Knowledge Cultivation, and Para-knowledge.

Figure 25: The indicators for the category knowledge harvesting



Knowledge Collection

My data shows how knowledge collection deals with input from external sources through participation in external projects, and external collaborations.

What knowledge is collected from participation in external projects will depend on what motives a project manager have for participating in external development projects. There can be several motives such as wanting to be a supplier for a customer, to be in front of development, to gain competence, economical considerations, to identify new development criteria, and to be able to keep employees by nourishing their technological interest.

Further knowledge collection comes from participation in research projects, and from being an OEM (Original Equipment Manufacturer).

Another way to collect knowledge is through participation in ERFA (ERFAring= experience) groups. These groups consist of members from a variety of companies, but from the same organizational level. ERFA-groups consist of project managers discussing common problems. A noted drawback when employees from the marketing department participate in an ERFA-group is that the topics discussed are mainly related to companies such as Coca-Cola, 3M, Levis or Marlborough, and not the black industry i.e. the welding industry. *Consequently*, this reduces the relevance of the input from ERFA-groups for the studied company.

External participation gives employees an opportunity to gain new knowledge, and to get knowledge on developments within the field. *Consequently,* participation in

research related projects such as projects with other partners, EU projects, or with foreign institutes, provides new knowledge, and networks. However, participation in external projects requires the company to know when their knowledge is needed in the external development process, and they need to feed the new gathered information back into their own development projects.

Make Knowledge Visible

To harvest knowledge requires identification of what information the different projects need, and it requires ability to identify, distribute, and control knowledge. What knowledge to distribute and control, depends on what products to develop and what knowledge employees' have.

Knowledge is made visible either through a better distribution of internal knowledge, or by getting knowledge input from external sources by assigning external experts to project groups. Moreover, knowledge is made visible in meetings with subsidiaries, employees, service personnel, and representatives from the sales department, and in discussions with partners.

The company's use of software tools such as MES (Manufacturing Execution System) for production and ERP (Enterprise Resource Planning) increase the visibility of knowledge, and help to identify knowledge lacks. Further, the use of prototyping helps to make knowledge about the product visible. *Consequently*, both the use of this software and prototyping contribute to identify what the product will look like, and the knowledge needed to develop the product.

Knowledge Introduction

Development does not start from scratch. The basis for product development is years of experience that a project rest on from the start. The company indulges in collaboration with the university through external projects to gain access to knowledge the company lacks. These external collaborations provide an opportunity to update the company's knowledge on recent technology and give access to knowledgeable persons. When committing to collaborations with persons, and institutions outside the company, it is important to promote the company, the history of the company, and the company values. Being able to promote the company applies even when using knowledge from outside in marketing tasks such aid from a journalist, or a photographer.

Furthermore, working with knowledge either internally with employees or externally with partners, requires much effort from the company. In addition, when the company chooses to engage in collaborations with external partners, breaking up such collaborations can be costly due to the time and resources put into the partnership. The company invest in their partnerships, and therefore do not replace collaborators often.

According to the employees' they feel like they are selling their soul every time they establish a new external collaboration. Because, an external partner needs to know how the development process is conducted in the company, and this require openness and trust in the external partner and visa versa (the external partner needs to trust on the company).

An obstacle for joining forces with potential external partners is to have time to absorb the external information. However, to be useful for the development projects in the company the information from any source, whether external or internal, needs to be supplied gradually into the development projects. Nevertheless, the development employees describe external collaborations with partners as exciting for the company, due to the different perceptions external collaborating partners represent.

Nevertheless, to harvest knowledge from collaborations requires investments. Establishing a relationship with an external partner means to market the company in an engaging way. However, this requires the development employees' to find the tune with external partners. The development employees' do not want to repeat their explanations relating to the background for the projects, the background of the company, and the background for what they want to get out of the actual collaboration. Therefore, it is important to have continuity in collaborations. Continuity in relationships ensures that collaborating partners have knowledge of the company's product portfolio, competence, and requirements to products. Despite the importance of external collaborations for harvesting knowledge, and to learn from external personnel, a claim made is that there is more to learn from project mistakes.

Use of intranet causes project transparency within the company, since everybody has access to everybody's documentation, and it gives a better overview and less project secrets.

In some cases, it can be more efficient to buy knowledge externally, or to outsource knowledge. This is the case if there is knowledge the company do not want to posses.

Knowledge Deficiencies

Knowledge deficiencies describe under what conditions knowledge lacks occur. Loss of personnel means loss of knowledge, even though the knowledge in the remaining work force keeps on being updated as work proceeds.

Engineering knowledge accumulates over the years, making it priceless, and when personnel leave, it is a large hurdle to overcome the knowledge lacks.

To ensure knowledge is spread in an organized way, employees help each other by sitting together and discussing problems, or an expert is included in the development group to share his/hers knowledge with the group.

However, maintaining close contact with former employees, through regular meetings with them to harvest from their knowledge, helps to compensate for knowledge lacks. Therefore, former employees represent a resource supply for the company.

Letting an expert into the development group can give access to tacit knowledge, a type of knowledge that can only be discovered by working closely together with the expert.

The company finds it equally important to know what knowledge they do not want to possess. Then the *strategy* is to purchase this knowledge when needed. *Consequently,* knowledge deficiencies are not only to know what knowledge is lacking, but also be able to identify if there is a need to build up a particular field of knowledge.

Knowledge Cultivation

Individuals' knowledge, their need for knowledge and further education emerges in the appraisal interviews, and the aim is to make development staff into generalists. When employees become generalists, anyone of them is suitable to do product development. Project employees are assigned to projects based on their education and skills.

Individuals' competence builds up by changing their tasks, assigning them to new tasks, and ensuring they attend courses. To be able to construct the perfect product drives the development personnel. Product development is not a one-man-show. Machines consist of hardware and software knowledge, and to create products requires the right number of engineers with both software and hardware knowledge. If the engineers are technology orientated, also the project group will be focusing on technology.

To update employees knowledge takes time, and can make it difficult to reach the production norm times. Norm times define what should be possible to produce under normal conditions and with normal speed. Therefore, MTM (Model Time Measurement) knowledge possessed by the company vastly diminishes when the company looses employees who have norm time knowledge. However, as work proceeds the MTM knowledge is updated. Nevertheless, updating MTM knowledge takes time, and the norm times will get poorer and poorer.

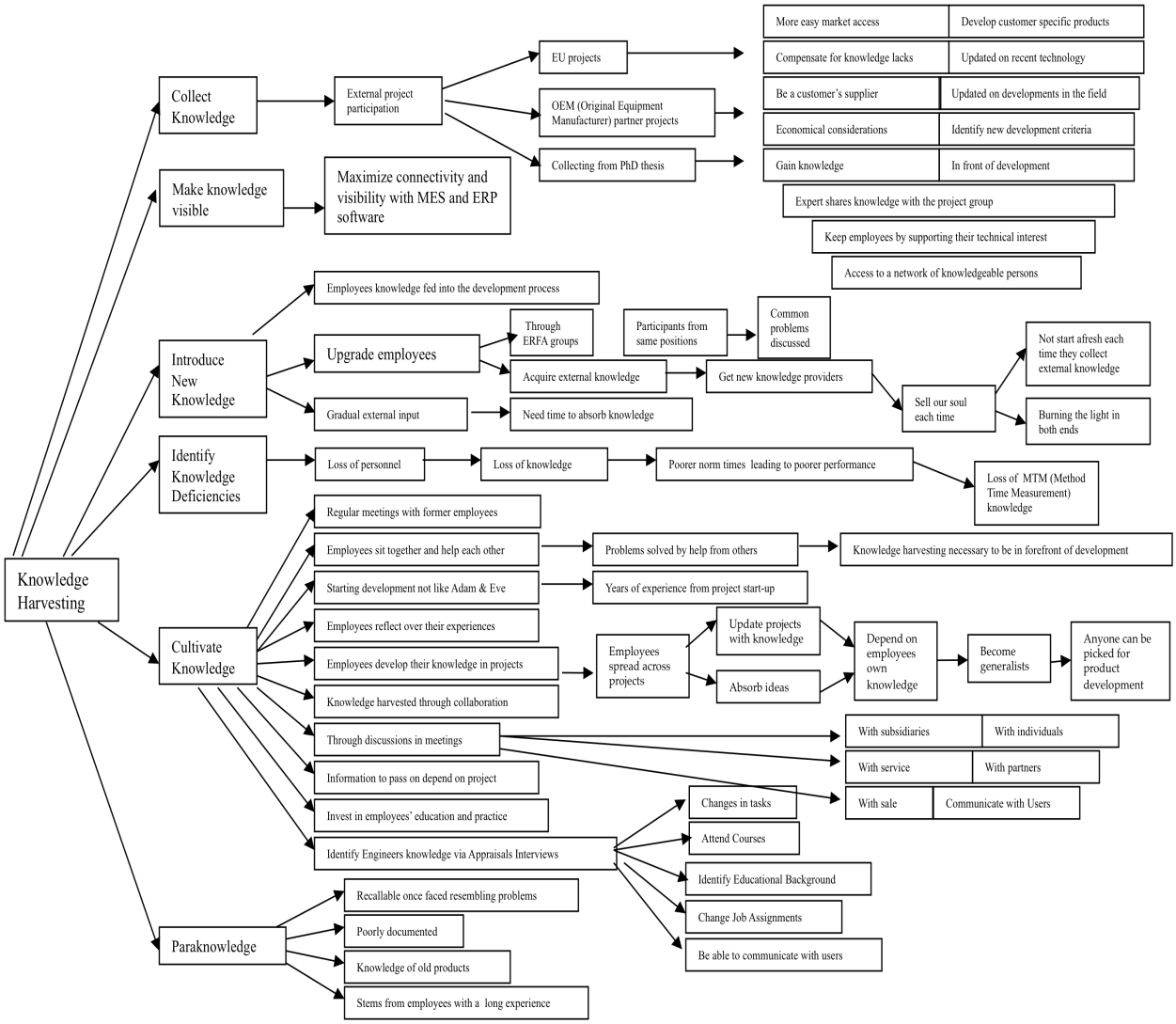
Para-knowledge

A particular type of knowledge, para-knowledge, defines a knowledge based on having long experience, and historical knowledge. Employees possessing para-knowledge for instance have knowledge of old machines. This knowledge is poorly documented, and the knowledge would be lost if they left. Employees having para-knowledge are able to recall their knowledge, and to suggest a solution when they are facing problems similar to problems to their past experiences.

Hence, knowledge considerations deal with distribution of knowledge and what individuals' shall know, and to harvest this knowledge when needed.

Conditions for Knowledge Harvesting

Figure 26: A summary of the category knowledge harvesting.



7.10 Concluding on the Developed Categories

The nine developed categories have in common that they emerge from interpreting participants' reflections over their activities in the development process.

A development philosophy emerges because of dealing with the nine categories. The core in the development philosophy is to ensure a dynamic planning of by continuously evaluating ideas and measuring the production capacity, processing time, marketing strategies, and products' portfolio.

Moreover, employees' knowledge is stimulated and their behaviour regulated. In practice, this happens through regular meetings, by making an effort to understand employees and customers, by encouraging employees' motivation for a project and allow employees to develop knowledge. Failure to communicate correctly with employees will cause violation of the product development process.

The development process can be seen as an organizational evolution where changes in technology, changes in procedures, changes in work processes, changes in role-play, changes in collaborations and implementation of these changes, result from the participants continuous adaptation of their understandings to reality.

8. Trajectories Caused by the Project Timeline and the Project Decisions

In order to identify the dynamics within product development projects, it is necessary to demonstrate how the developed categories fluctuate during the development of a project. In my data, I found two factors that influence how the develop categories unfolds. The first being project timeline, and the second being project decisions.

1. **Project timeline**.
2. **Project decisions**.

Project timeline represents the time employees' use on development work. I found in the data that the employees use different descriptors such as: **year, month, week, day, old, before, past, then, previously, today, and now,** to describe project time.

Project decisions will move the product development project in a particular direction. These decisions are related to the nine concepts develop in chapter 7:

1. Project emergence,
2. Strategic Considerations,
3. Flexible and Coordinated Project Planning,
4. Binding to Market,
5. Inclusion on demand,
6. Project Manager Compliance,
7. Knowledge Harvesting,
8. Production Flexibility,
9. Cultural Traits.

As an example, when a decisions related to the concept, inclusion on demand, excludes relevant employees from the development group, this causes project closure. Project closure will effect the production, cause much manual steering, and re-do in the project.

My claim is that the project timeline and the project decisions are useful in order to spot how project decisions influence progression in development projects.

However, this requires me to analysing the data in a different way. I have therefore in this chapter not applied a GTIA (Grounded Theory Inspire Approach), but investigated the data by looking for the phrases **year, month, week, day, old, before, past, then, previously, today, now, and decisions affecting the nine identified concepts**.

8.1 Employees' Descriptions of Project Timeline

Two projects, here called the X1 and X2, were part of the research in the studied company. Project X1 was aimed at developing modules that could be used by many machines. Project X2 was aimed at developing machines as compact as possible. Two new machines resulted from the two projects, in addition to an entire package of machine types. The machine types have in common that they use the same plate dimensions and materials, regardless of what welding process the customers use.

On average the duration of projects in the company are around of **16 months** from the definition **phase** until the market introduction of the product: o**ne month** for the pre-investigation, **three months** for the business phase and **a year** for production or until delivery. In the business **phase,** information is collect from discussions with users, market considerations, from engineering considerations, and economic considerations. Once the business **phase** finishes, the design **phase** starts. Nevertheless, due to continuous expansions and changes one of the mentioned projects has been running for **four years.**

The development department corrects errors, and considers feedback from users the first **year** after product release. Consequently, feedback from the market about lacking machine functions will ensures revenue from the product when they are fixed, and satisfy users requests.

The development of machine X1 started in **January,** but already in **March,** a slight change in the project made it possible to generate additional components. The **new** components enabled the company to develop machines for new welding processes, by using an existing machine steering. In addition, with the new components' it was possible to start a new project aimed at the ESSEN fair in September, the X2 machine. The ESSSEN fair is the world's largest welding fair (Schweissen & Schneiden, 2009).

Hence, the development department started development of machine X2 in April 2000, which they wanted to finish **before** the ESSSEN fair. With enough personnel resources, the development team hoped an operating version of the machine would be finished by **June**. In order to get the necessary project resources, projects are synchronised to ensure adequate transferral of employees from one project to another. "Typically, once you finished your projects, **then** others were in the middle of theirs" (Informant B2JA010118, 2001). However, reductions in revenue resulted in fewer resources, and **delays** jeopardized coordination between resources in the projects.

Furthermore, in **May 2001,** the goal was to enter into production in November **2001** with the X2 machine. However, cutbacks reduced the project by three engineers. The development department was able to fill one of the vacant positions, but further recession in the company made it necessary to dismiss an additional engineer. Since the X2 project had a strong focus on new technology. However, the welding process in X2 was difficult to control due to technical challenges, and due to overrating how fast the technology

could work. Therefore, the project slowed down. Prototypes were not ready before **September 2001**, and trial production started in November 2001. Furthermore, being short on labour the project did not enter production **before January 2002**.

To get a good exchange of personnel between development of the machines X1 and X2, there could be no delays, since a delay in one of the projects would affected the other. "The need for men has been extremely underallocated...both in terms of resources and time, and the degree of completion has been extremely undertreated " (Informant B4KJP011217, 2002).

Technological delays in the X1 project, affected the progress of the X2 project. From the time of our first visit to our last in the company, the development group shrank from six people to three by April 2001, within a span of six months. Losing personnel caused loss of knowledge and left tasks unattended giving uncompleted products.

Loosing key personnel within the project group caused poor project management, because the project leader needed to handle both construction tasks and managerial tasks. Consequently, it caused a lacking connection to the sales force, to production, and to logistics. However, making standard machines according to sales prognosis requires a minimum of the machines in storage. Therefore, splitting production into series and order production enabled the company to deliver customer-specific machine on a short notice. Furthermore, the company produced ready configured machines with a delivery time of three days and customer specific machines within a delivery time of six weeks.

At a certain point in time, the production of more standard machines resumed. Whenever the amount of orders increase, the company can sell standard machines in storage, and in this way the production of standard machines provides a capacity buffer. The idea was to be able to have one production line that could handle both serial and customer specific production. Changes in production caused a reorganization into self-governing resource groups. According to discussions with other companies, making the resource groups function properly, could take up to five years.

Before, when the company used the Integrated Product Development Model (IPD), the marketing department evaluated the business in projects, and presented requirements to projects. Consequently, the development projects specifications grew.

For the development department, the aim was to specify the engineering aspects in the welding machine. But, since the marketing posed a lot of requirements, without being able to se how these would increase the project specifications and project cost, the development department focused on making the specifications as detailed as possible, in order to avoid apprehension. Moreover, with a detailed specification of a project, the development department could use the specifications to settle any disagreements with the marketing department. With a detailed specification, the development team can identify

what was agreed on, by looking at the specifications. In this way, the specifications became a reason d'être for the projects.

> "As I experience it **now** in relation to this, the problem **before** was that the marketing personnel by no means had an educational background that enabled them to be sufficiently capable to read and understand these specifications. Then they were inclined to say, indeed this is what we do, and **then** we did it. Then as a rule, one hardly managed to finish the product **before** they found out it is not this that we need and **then** very often it ends with using a large amount of time to discuss what we said that time. Therefore, the development personnel put their hand on the book and said: this is what it says here and this is what you get. This means that the development projects and the development department have been very technology driven" (Informant B2JA010118, 2001).

The management in the company consist of managers from all departments. Management approve phase shifts, take part in the product committee meetings, and release resources to the entire project. However, the product committee grew due to continuous expansion getting too many members. Furthermore, the managerial representatives participating in the product committee could not understand what they were expected to do. Furthermore, management wanted to focus on the business, but everybody had an opinion on the product and as one of the informant said, "whether or not the screws should be added" (Informant B2JA010118, 2001). Consequently, these meetings presented both large and small issues resulting in discussions of the smaller issues rather than the larger ones.

For every product gets a set of number values are calculated. These product values are used to increase efficient in the development process. The values accompany a project all the way to the market. These values changes according to how the income-to-cost ratio develops, and how the current value of the product develops.

Management's detail meddling in the product development project reduces with the adoption of the Stage–Gate model. "This is what management should look at and it is about getting management to keep their hands off of how the product is being developed since they have no qualifications for this" (Informant B2JA010118, 2001).

Viewing a new machine as a set of building blocks happens when the machine use parts from other machines. In a situation where a new machine was lacking a user-panel, but where the development department had too few resources to produce a new effective and efficient Man-Machine interface, they had to use an old-fashioned user-interface adopted from another machine.

"We had planned to make a project that would require new steering, and we had aimed at getting the project together by reusing the old steering. **Then,** we made an arrangement to reuse the old steering to start with and that within **a year** we should make a new steering; in this way, we could get two steps ahead on the product. In addition to this, we wanted to use some part elements and then update some versions of something we have **today** which is in the market and familiar to the customers. We **then** continued with the project and reused some of the steering, and it soon became apparent that the project we had completed, with the same steering, had some defects. Consequently, we could not live with this in a new product a year from now. We said we should concentrate on developing products from our product portfolio **today** that have an optimally calculated price, which will contribute substantially to our earning power. We decided to develop them first because we have the resources for it. **Then**, if we could employ a couple of men, we could develop a new steering system with about a **half year** delay which could move us into the steering market since there is more business there" (Informant B2JA010118, 2001).

8.2 Employees' Identification of Project Decisions

The product development participants perceive their organization as informal, but **decisions** still need clearing with the managing director (Informant B3JP010522, 2001).

Furthermore, they practice an old-fashioned **decision scheme** where the managing director wants to have overview and control of the development process, but this changes as the company adopts the new Stage-Gate model.

From a production, perspective, to ensure that the managing director makes fewer **decisions** that will influence production, requires formal guidelines describing the development process (Informant B3JP010522, 2001). However, the development model and the strategic plans influence employees' workflow during product development. Furthermore, the adoption of a new development model with a stronger emphasis on users, requires a reorganization of the product development process to ensure that knowledge of the user patterns are considered during the development process i.e. what an informant called "lifting the cheese lid a bit" (Informant B2JA010118, 2001).

To identify what users the different welding machines will target, the company defines a product strategy. The product strategy chosen in the company was a product pyramid. A product pyramid places emphasis on the middle market segment containing the largest volume.

> "The phase where we say we are in the welding business; our eyes and ears are opened to what is happening within this industrial field and what requirements the customers have for such machines. This triggers many of our product projects' first initiatives where we see a market segment in need of a particular type of machine. Then one follows this purposefully and makes a machine for a particular industrial segment. This is how it started, and this is a different way of doing it than we did before, because that time we did not know we were in the welding business. This was something we should look at and this was an opportunity, and this is how it worked for many years" (Informant B2JA010118, 2001).

When the development of a product focuses purposefully on a particular market segment, the cost price decreases, and consequently the company avoids producing products with too advance functions. The main phases of product development are the pilot phase, the production phase, and the guarantee phase. The product strategy group evaluate the first two phases of the product development model by considering the consistency between incoming ideas and the product portfolio in order to make phase **decisions**. The product strategy group then decides to start a project and performs a pre-investigation. During the pre-investigation, the project leaders use 14 days efficiently on the telephone and at the research desks, to build their hypotheses describing what new machines they should develop.

For the development, team the development responsibility covers the guarantee phase and lasts typically one year. When the company adopted the Stage-Gate model, the guarantee phase coincide with the business phase for the next project. Moreover, without a strict time schedule for projects causes a blurring project responsibility.

The new product development model introduces gate meetings in two parts. The first approval part considers a review report. Then a short business-oriented meeting presents the new looks, and follows up the business in the project. The gate meeting builds and modifies the project's values. Moreover, by applying the documentation and the key figures the project either proceeds or not.

> "Even when the pre-investigation phase has ended, my project had been redefined three times over the last two months. First, budget considerations reduced the project by half after the concept specification and we had already started the pre-investigation phase. Then we ended up with a smaller project" (Informant B2JA010118, 2001)

Moreover, applying the new product development model reduces the number of projects from three to only one project.

> "Because now we have become so business oriented, and have a business follow-up scheme where we calculate the value of the firm. Then the project leader provoked the sales department, claiming that this was such a poor project so it could not be economically feasible to run it. Then some other thoughts were brought forward and we changed the composition and then we threw it away and got more time to run a newer project that we do not have in our portfolio today, which could be made better and vastly increase our business" (Informant B2JA010118, 2001).

The new product development model, i.e. the Stage-Gate model, focuses on how the product fulfils specifications and market demands. Nevertheless, only fulfilling the specifications felt unsatisfactory without being able to sell the developed product. Furthermore, being able to sell the product essentially affect the company's economic outcome, regardless whether the development personnel do their job technically or not. Generating a poor economic outcome felt discontenting, and the development of such products did not shelter the development for a long time. It felt rewarding to see cash yielding products coming off the production line.

> "If you go and wake one of these development engineers one day when he sleeping after dinner and ask him what the primary goal is here, he will say that it is to comply with the specification requirements. Then one could say, 'What will it take to succeed?' and they will be able to maintain the specification requirements. Then you could ask him, 'What is the most interesting and challenging aspect of this work?' and then he would reverse himself and say that it was to be able to work with the new signal processes or anything else that sounds smart. We have recently had one of the other project groups, which are very technology oriented, and tried to drag them into a strategy discussion. The development team knows conspicuously little about how to use the welding machine and do not know a thing about the user's requirements. In general, our machines are developed with too many smart functions. The Canadian professor (My insertion: Professor Cooper) very provocatively put it when he said that features are generated rather than benefits and they are of no use for the users, so we have to redo it"(Informant B2JA010118, 2001).

In the old development model, i.e. the Integrated Product Development model (IPD), the technicians remain in the background analysing what technology they want to apply, and in front of them stands the marketing department.

It is considered important that the technicians are able to analyse the requirements to a new product based on considering users needs. However, in order to be able to take users needs into consideration, the development department have to consider feedback from the marketing division. If the marketing division are not able to communicate users needs in an understandable way to the development groups, then too advanced machines are produced that are unsuitable for their intended users. This illustrates the importance of good communication, before starting to define the requirements to a machine, in order to avoid too complex machines.

> "In reality, I think that the way we start learning is to discuss things with the project leader in meetings, where we ask how it is going with the project, what kind of things are happening, and get to know what you did with this, etc. If a person is not there anymore, the knowledge is not there" (Informant B2JA010118, 2001).

In the old development model, clearly defined specifications identify how to develop the product before delivery. Moreover, further wishes from sales and marketing were blocked, and therefore there were fewer amendments during the development of a machine. Furthermore, the old product development model made it possible for the project manager, to combine doing construction tasks with being a project manager.

However, the new development model required integration across the organization and a stronger emphasis on business development than on the construction of products. The new development model made the development department responsible for producing a working product. Furthermore, with a working product the development department is able to satisfy a market need defined by the sales organization and by the end-user, the welder. However, the new product development model increases administration and responsibility due to more organizational integration and reallocation of personnel.

The regular weekly meetings between production, planning, and logistics, discuss the delivery overviews. Meetings that are more informal discuss the production prognosis. Every fourth night planning conducts a meeting where the sales department considers their sales prognosis, but without involving the development department.

Loss of personnel or re-assignment of personnel, withdrawal of economic resources, and loss of technical personnel causes reduction in the resources necessary to complete the project. Such reduction promotes a mini edition of the project, and to plan new production lines using the principle of mass customization. However, mass-customization presents a problem since it make it difficult to control the capacity for order production, and require a more complicated production line. With these changes in the production,

the challenge is to run small series efficiently and to reduce time spent on logistical task by reducing the time used on fetching parts.

8.3 Influences of Project Timeline and Project Decisions on Product Development

The actual time of a development project is governed by two central elements, the time it takes to develop a machine, and the time it takes to correct errors in the developed machine.

Furthermore, the challenges met during the development process influence the time it takes to develop a machine. New technology, new knowledge, and lack of personnel resources influence the efficiency in the development projects, and the company need to be able to handle this.

Since, there is only a limited amount of personnel, projects are synchronized to optimizing use of personnel. The challenge with synchronizing projects is that once one project is finished, another project is only half way. This makes synchronization of projects challenging, and how this is handled, will decided if personnel resources can be transferred between projects.

Implementation of new technology in the machines influences the development process and causes delays. Either, because of the time it takes to understand and implement the technology, or because of delays in getting the technology. Delays caused by technology can also result of not paying enough attention to the degree of completion in a product.

The decisions taken because of using the Integrated Product Development model (IPD), led to a more elaborate product specification. Because, focus was on not forgetting anything during the development of a product, and to avoid being punished if the product did not sell as expected. Rather than focusing on earning money, the centre of attention was to avoid missing any of the requirements to a product.

The decisions made to follow the Stage-Gate model caused less meddling from the management in the details of the project. Therefore, formal guidelines are necessary to describe how to conduct the development process.

The adopted Stage-Gate model caused challenges relating to responsibility during development process. Because the development phases such as the guarantee phase coincides with the business phase for the next project, the Stage-Gate model requires a strict time schedule for projects in order to get a clear distribution responsibility for tasks. The adoption of the Stage-Gate model also helped to reduce the number of projects.

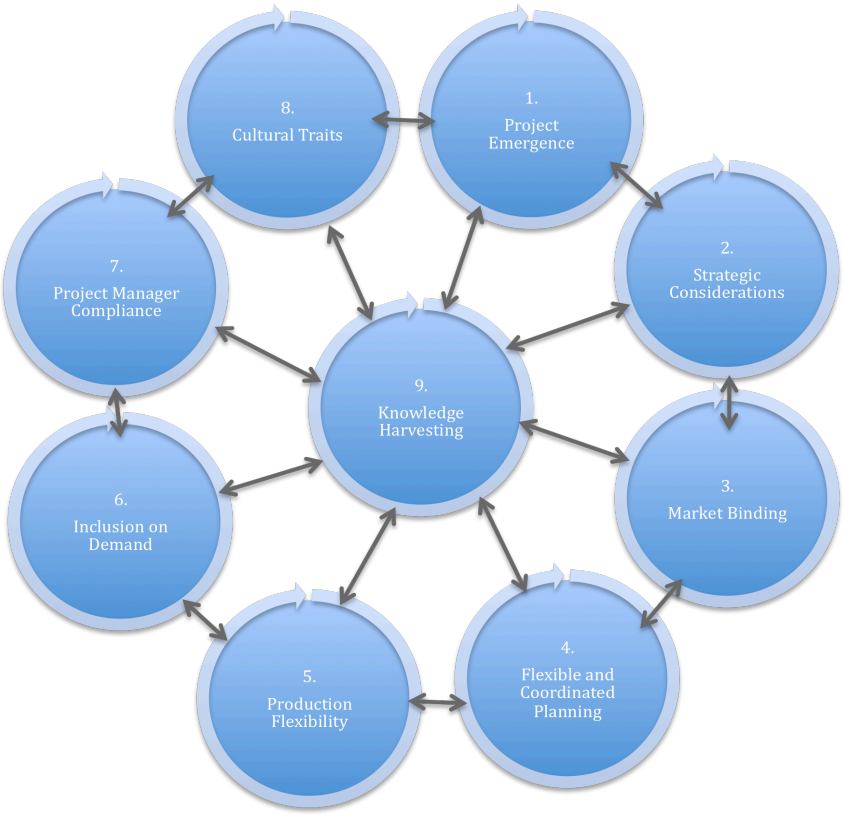
Both the project timeline and the project decisions taken because of following the adopted development model are tightly intervened, and both affect what direction the development process takes.

9. Concluding on Knowledge Harvesting

The research question raised in this thesis aims to understand how employees' comprehensions of product development projects change the adopted development model, and how this knowledge can be used to create a new model better fit to their reality. By categorizing and modelling employees' project development understandings, I have tried to answer this research question.

Current development models pay little attention to employees' comprehension of product development and the effect of employees' participation in organizational learning processes on product development. Moreover, current development models insufficiently incorporate the dynamics between innovation process requirements, and participants' organizational learning processes. In my thesis, I develop nine categories to explain employees' interpretations of product development projects, and their significance for a company's adopted development model. The nine categories are: project emergence, flexible and coordinated project planning, strategic considerations, project manager compliance, inclusion on demand, binding to market, production flexibility, cultural traits, and finally knowledge harvesting the core in the organizational learning processes.

Figure 27: Overview of the nine categories developed in this thesis



The categories in figure 27 contain descriptions of how the participants in the innovation process constantly adapt the development requirements to the problems at hand, and harvest knowledge in order to be able to solve the problems they are facing.

The categories in figure 27 emerge from researching product development in a company manufacturing welding machines, using an approach inspired by the works of Glaser and Strauss (1999) on Grounded Theory (GT).

9.1 The Nine Categories

The nine categories in figure 27 identify employees' comprehensions of product development during organizational learning processes, and how they organize and participate in the product development process.

The category, project emergence, defines what factors influence what products the company chooses to develop. Project emergence involves identifying how to restore old projects, and to reduce detail meddling by the management. Project emergence involves knowing what types of technology pieces would result from different projects, knowing how to implement components to get more products out of a given product or no product at all. Project emergence involves having accurate market information, user, and customer information. Furthermore, a central factor of project emergence is to identify how product lifetimes influence the flagship products in the company. Flagship products represent the company's most selling products over time, and provide a steady income for the company. When employees possess project emergence knowledge, they can decide what type of products to develop for whom and with what qualities.

The category, strategic considerations, helps employees to identify the elements guiding the company's innovation policy. Taking strategic considerations helps to get a solid business plan that ensures the necessary growth and competitive edge of developing a product. Furthermore, to be able to make strategic considerations requires an overview of the product design and the development phases. The strategic considerations anchor the project in the organization by taking into consideration projects portfolios, and ensuring that employees know the company strategy. Part of the strategic considerations is to define customers' needs through market investigation and interacting with customers. However, strategic considerations need to consider the influence of users' requirements and to reduce the influence of employees' or customers' hobbyhorses. Taking strategic considerations also involves having a clearly defined top strategy. Furthermore, part of the top strategy is to decide what type of producer the company wants to be. According to the patterns of innovation in the company, this involves deciding either to be a producer for a supplier such as an OEM (Original Equipment Manufacturer), to be a scale intensive producer, to be a specialized producer, or to be a

producer that is research oriented. This is an explicit decision resonating well with Keith Pavitt's (1984) theory on what characterise companies within certain production sectors. However, my research demonstrate the company is conscious about what type of production sector it wants to be in, based on the strategic decisions the company makes. When employees have strategic knowledge, they focus on the market during the development process. Strategic considerations help the company to orientate their innovation process towards relevant and profitable market segments.

The category, flexible and coordinated planning, describes how reduction of negative influences on the development process promotes project progression or project results. To plan projects, the employees need to know the renewal pace of products within the industry, the different project control elements influencing project progression, and how scrutiny affects knowledge distribution and development. However, flexible and coordinated project planning depends on stimulation and regulation of employees' behaviour. Moreover, when employees are ignorant of tasks, this reduces project control. A flexible and coordinated planning involves being able to handle activities such as idea evaluation, cuts in resources, change of project manager, change in production, task transferral, and reorganizations. Flexible and coordinated project planning requires identification and understanding of the factors influencing project progression.

The category, market binding, describes how the products are tied to the market. The decisions that tie a product to particular markets, are taken when dealing with problems related to dealer's disloyalty, increase in automation of welding, generic products, users development wishes, and shrinking project descriptions. The development participants handle these issues by working with dealers, technical producers, suppliers, customers, users, and competitors. Consequently, the development engineers consider the developments within the industry and translate these market developments into product specifications. An increase in emphasis on the market changes the engineers' development perspective from a technology-oriented perspective to a market-oriented perspective. The consequences of these developments are that products are produced for particular users or market segments, and this increases the company's vulnerability in terms of commercial success.

The category, production flexibility, defines how to run production as efficiently as possible. Using standard modules and recycling output from earlier products make production flexible. Further, flexibility in production happens by reorganizing production into serial production. Serial production is efficient and allows short notice delivery of customer specific machines, using standard modules. Furthermore, by combining elements from old machines in new ways, production gets even more efficient. When combining elements to produce new welding machines, it is possible for the company to develop a package of different types of machines with diverse dimensions, and where the

machines are usable for distinct types of welding materials. Furthermore, production can combine the use of standard modules in production with adjustments to the exterior of the machines. Such combinations make production efficient and allow the company to satisfy user requirements and to make user-friendly machines, only by changing the exterior of the machines. For the participants in the innovation process, production flexibility depends on a right distribution and regulation of resources. It involves optimizing production by considering how to reuse technology, focus on mass customization by standardizing, and combining standardizing with purpose building. The use of outsourcing, prototyping before producing new products, and organizing the production into rotating groups make production even more flexible.

The category, inclusion on demand, explains the participants' understanding of how to include personnel in the innovation process. Personnel contribute to the innovation process based on periodic involvement. The project manager responsible for the development project, regulates the periodic involvement, the intensity of involvement, the timing of involvement, and what personnel to involve. If development groups refuse to let others in, project closure occurs and brings the innovation process to a halt. To overcome these problems, the company needs a dynamic product development department, and the project manager in particular need to identify lacking involvement and to integrate the right people. Focusing on inclusion on demand means knowing what development personnel is needed at what time, where, and how much.

The category, project manager compliance, describes what qualifications a project leader needs based on how participants in product development view the project manager task. A project manager must be involved early in the product development, be qualified, and be willing to take on project responsibility. The project manager collects project knowledge by ensuring project personnel with capacity, and by including them in the development project. To uphold product development progression, the project manager needs to inspire the development team, to keep time schedules, to coordinate the project, and to run the project until completion. Being a good project manager is part of a persons' personality. Hence, to get success with development projects, the project manager needs more than previous project experiences and education. A good project manager needs a personality fitting with such a job.

The category, cultural traits, describes the organizational requirements to a good company culture. A good culture allows development employees to raise their opinions and present their arguments in favour of a project or not. A good company culture stimulates, inspires, and integrates people. Applying measures such as possibilities for employees to learn new things, an efficient production, an active employees union, and company facilities such as a fitness studio, help to build a good company culture.

The category, knowledge harvesting, explains how the company cultivate knowledge by upgrading employees' knowledge, by collecting knowledge, by making knowledge visible, by introducing new knowledge, by identifying knowledge deficiencies, by cultivating knowledge, and by considering para-knowledge. Para-knowledge involves knowledge of older products. A challenge with para-knowledge is that it is sticky. Because para-knowledge is sticky and tightly related to the activities undertaken by the persons having this knowledge, it is difficult to transfer para-knowledge to others.

Knowledge harvesting is the central category permeating the product development processes described by the participants. Therefore, knowledge harvesting is discussed further below.

9.2 Knowledge Harvesting

Knowledge harvesting is the hub in product development and explains how organizational learning processes influence product development projects. Knowledge harvesting is a result of employees' engagement in a product development project. Within product development, engagement results from being included. The appropriate employees are included in the development project when the project manager, who has knowledge about employees' knowledge, needs them.

The first element in knowledge harvesting is knowledge collection. Knowledge collection happens through participation in international projects, through working as an OEM, through participation in ERFA (ERFAring = Experience) groups with other companies, or by collecting research knowledge. Knowledge collection gives the company an easier market access and enables them to compensate for knowledge lacks, to gain new knowledge, and to be a customer supplier. Furthermore, the company by collecting knowledge in the mentioned ways, can develop specific products for specific markets, can get updated on developments in their field, can identify new development criteria, and can be in front of the technological development. In addition, by collecting knowledge from experts and include the experts in project groups, the company gets experts to share their knowledge. By focusing on collecting knowledge, the company avoids loosing their engineers by supporting their technical interests, and the company gets access to a network of knowledgeable persons.

The second element in knowledge harvesting is to make knowledge visible for the employees participating in the development project. To achieve this, the company applies MES (Manufacturing Execution System) and ERP (Enterprise Resource Planning) software. Such software facilitates distribution of information about project progression to

all parties in need of this information, and helps to increase connectivity and visibility in the project.

The third element in knowledge harvesting is to introduce knowledge into the development process. Knowledge introduction happens by feeding employees knowledge into the development process. Since employees need time to absorb knowledge, it is important to do this gradually.

The fourth element in knowledge harvesting is to identify knowledge deficiencies. Knowledge deficiencies happen because of personnel loss. When the company looses personnel, they also loose knowledge, and this will lead to poorer norm times and to poorer performance.

The fifth element in knowledge harvesting is knowledge cultivation. To cultivate knowledge, the company needs to have regular meetings with former employees, in order to harvest knowledge from them in a transition period after being employed in another company. Cultivation of knowledge happens as employees sit together and help each other, but also when employees reflect on their own experiences. Knowledge is further cultivated as employees develop their knowledge in projects. This happens by spreading employees across projects. Thereby, the employees can update projects with their knowledge, and absorb new ideas and experiences to use in other projects. In this way, employees get a broad spectrum of project experiences, and they become generalists. When employees have become generalists, it is possible to pick anyone of the employees for new projects.

Further cultivation of knowledge happens through collaborations and through discussions in meetings with subsidiaries, service, partners, sale, users, and other individuals. Knowledge cultivation also requires knowledge of what information to pass on in relation to what project, and it requires investment in employees' education and practice.

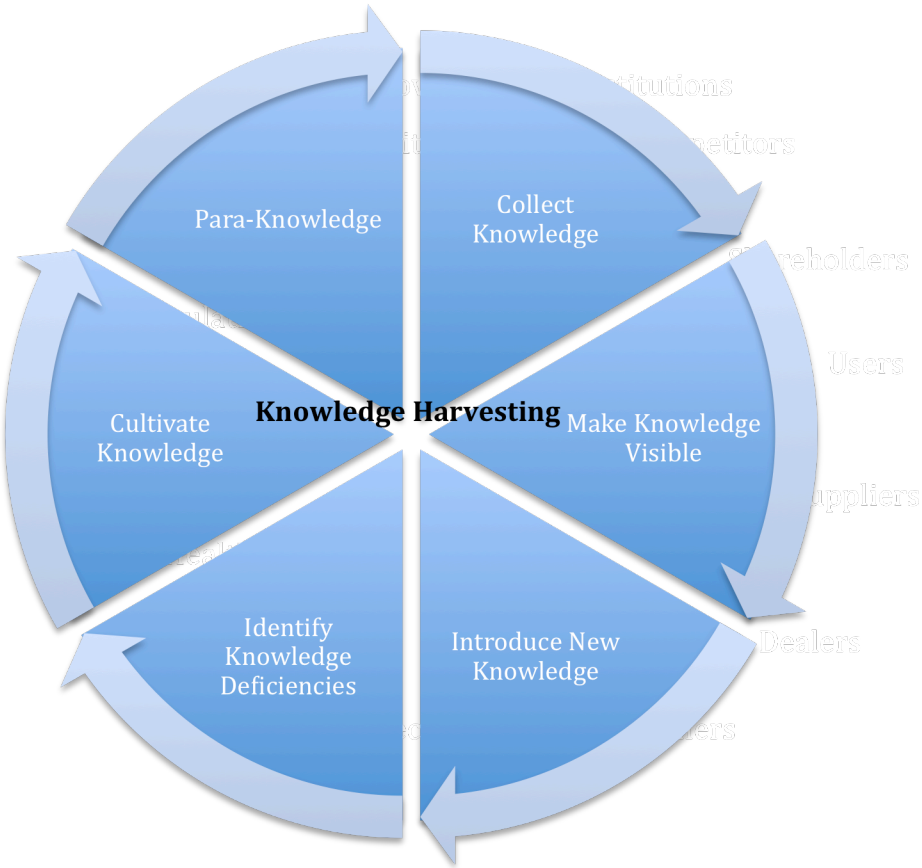
For knowledge cultivation to be effective, it is necessary to identify engineers' knowledge via appraisals interviews, and to identify if the engineers want to change work tasks, attend courses, change job assignment, and whether they are able to communicate with users.

The sixth element in knowledge harvesting is para-knowledge. Para-knowledge has four characteristics; stem from long practice, related to old products, poorly documented, if documented at all, and recallable once faced with a problem similar to a problem in employees' past.

All of the sixth elements of knowledge harvesting happen as employees solve problems, and reflect over their experiences. While social learning processes happens because of interacting within a given social context, individual learning processes result from stimulating senses and combining these sensuous impressions with some cognitive

image stemming from some previous experience (Mead, 1912; Lave, 1988). If I apply Mead's (1912) perspective on the category knowledge harvesting, it means that what employees' bring to a development project are previous experiences from earlier actions. Employees' pervious experiences are required to run new product development projects. However, this depends on whether the employees are knowledgeable. Therefore, knowledge harvesting can lead to new or modified products, only when employees are encouraged to use their prior knowledge, and to consider the para-knowledge in the company.

Figure 28: The category Knowledge Harvesting based on employees' comprehensions



In the studied company, the company's adopted product development model guides the knowledge harvesting processes and binds the product development process to the market. This is a result of making engineers and project managers responsible for market success. To get market success with products, the engineers and project managers need a stronger emphasis on earnings and a closer collaboration with users.

The work activities and practices advocated by knowledge harvesting demonstrate how a knowledge management process links people to activities and to responsibilities. The category knowledge harvesting supports Gherardi's (2000) claim that practice

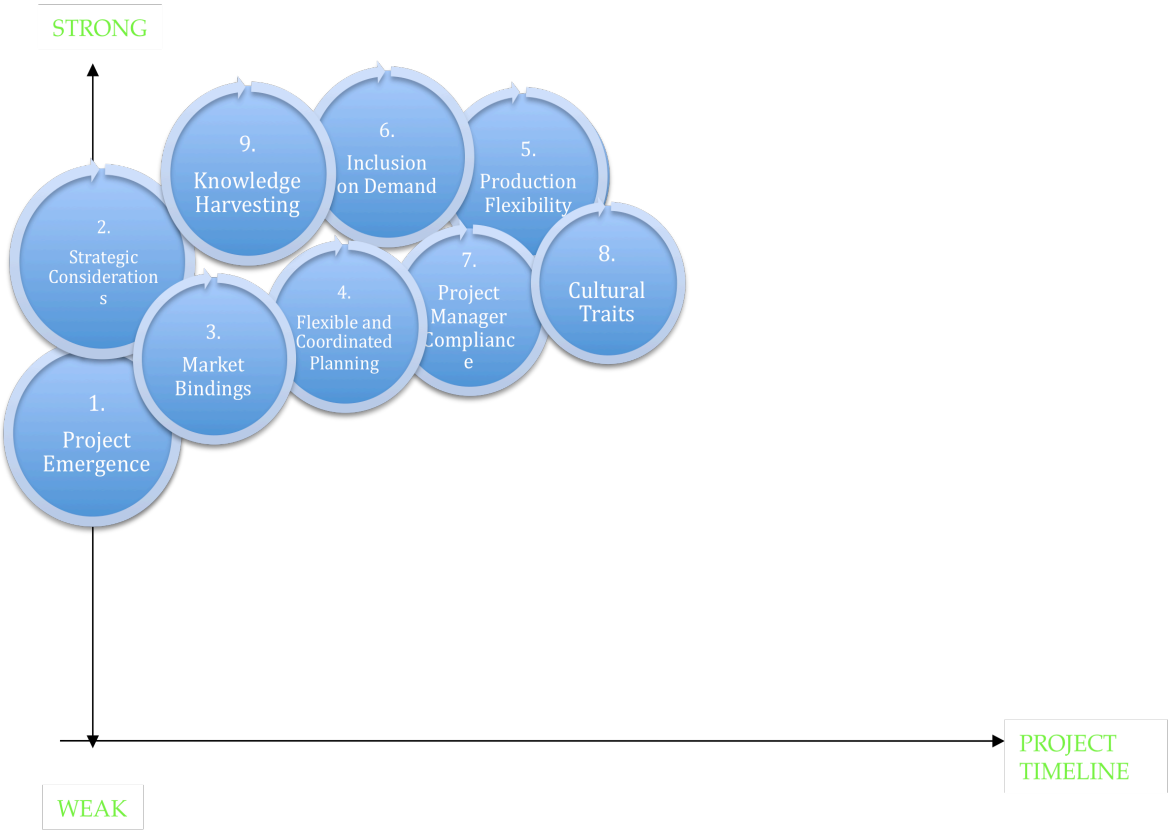
connects knowing with doing, but knowledge harvesting also expands his claim by saying that employees comprehensions and responsibilities connect knowing with doing.

9.3 The Dynamics Regulating Employees' Product Development

The content of the developed categories explain what decisions the employees consider during a product development process based on how they interpret the process. However, participants' understanding and knowledge of the product development process adjust and change over time, and influence progression in the development process. Moreover, development models need to incorporate employees' dynamic understanding of the process in order to understand how this influences project progression. Employees' understandings influence management decisions, and this either strengthens or weakens progression in a project during the timeline of the project.

Figure 29 incorporates project decisions with the project timeline and shows how the nine developed categories fluctuate during the innovation process. The categories move up or down on the strong/weak y-axis, depending on how the meaning of the categories changes during the project timeline based on what project decisions are taken related to the content of the different categories.

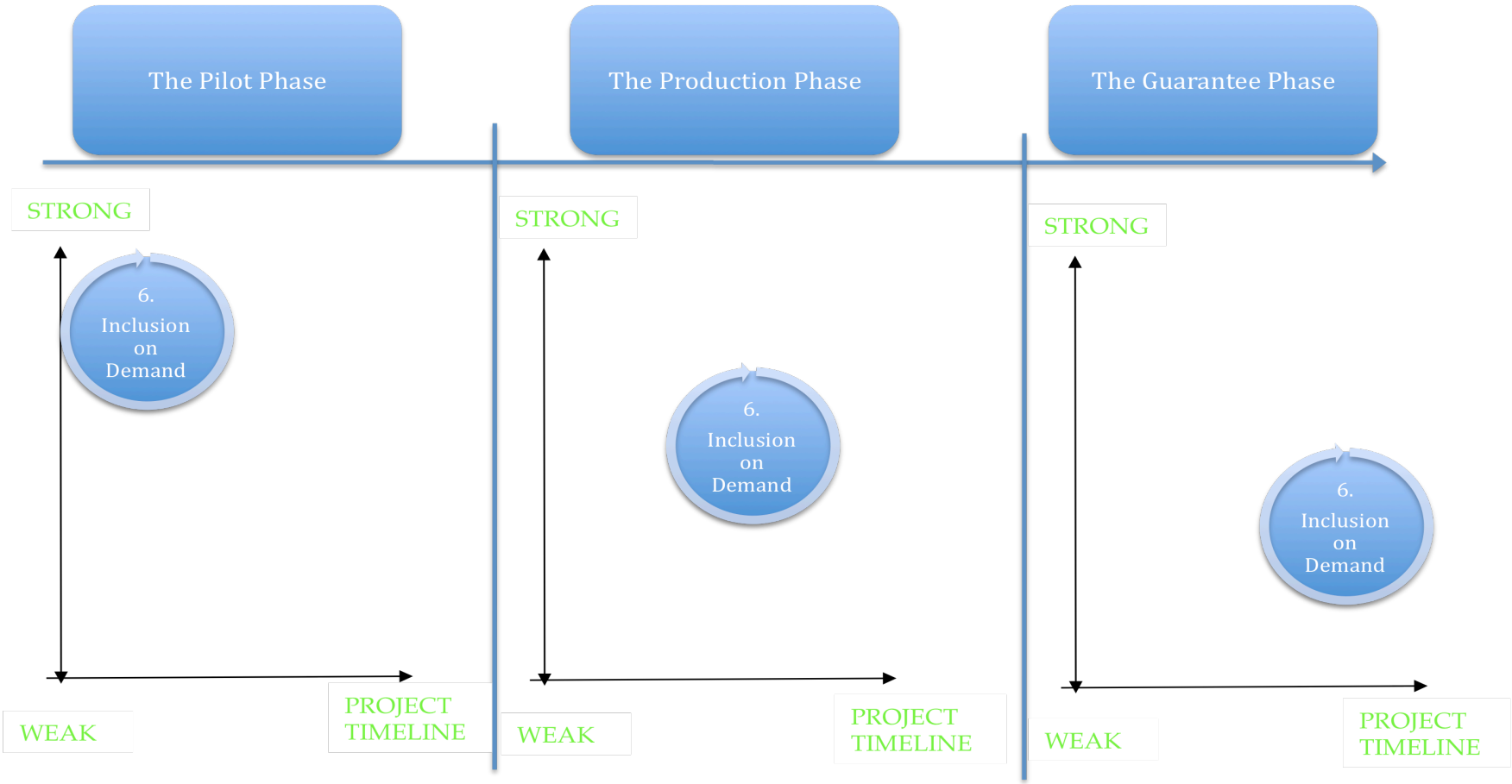
Figure 29: Dynamic representation of the categories describing participants' understandings



In the model above, the categories move between strong or weak based on how project decisions influence a project over time. Furthermore, the fluctuation results from changes in participants' interpretations of their daily product development process, and the decisions made during the process. Moreover, by simulating and changing the factors influencing each of the nine categories a new picture of the development process evolves. Continuous adjustment of the nine categories will keep the development process on track and reveal knowledge lacks. Following up the nine categories during the development process, helps both the project manager and the employees, to ensure progression in projects. Subsequently, the nine categories are applicable for the phases of a development model such as the Stage-Gate model or the Integrated Product Development model.

Hence, the model shown in figure 29 is relevant in any of the development phases of a project. I illustrate how the model works in figure 30 below, using the category Inclusion on Demand. The Inclusion on Demand category moves from a strong focus at the start-up of a project, the pilot phase, and then in the production phase the category weakens because many of the development participants are not needed anymore in the process, and then finally in the guarantee phase only a few of the participants from the development process is required.

Figure 30: Model showing the knowledge trajectory for the category Inclusion on Demand during the product development phases.



Applying the model in figure 29 to new environments and innovation processes, will add additional understandings and values to the categories. This will strengthen the applicability of the categories, and make the categories more vigorous.

As categories expand, they become autonomous and independent from the context where they originated, and the categories become *generic categories*. Nevertheless, to become generic categories researchers must apply the developed categories to new cases. Furthermore, the content of the categories may change, without changing the name of the category. Application of a Grounded Theory Inspired Approach (GTIA) means to be able to name and to label. Moreover, application of the model in figure 29 to new cases and innovation processes, can strengthen the relevance of the categories.

New researchers applying GTIA to generate categories using the same data, will not necessarily end up with the same categories. Different perspectives will yield different results depending on the researcher's perspective, experiences, emphasises, and abilities. Therefore, the idea behind generating generic categories depends on how feasible, interesting, and relevant they appear to other researchers and the field in question. Subsequently, if researchers see the categories as relevant, they might apply them to new cases and innovation processes.

9.4 Knowledge Harvesting in User-Producer Relationships

The literature review on learning in user-product relationships in chapter 3 emphasises the consumer as the driving force towards commercialization and diffusion of products (Ekins, 2010).

Having limited knowledge of welding the producer needs to harvest knowledge from the user. The producer needs to know how the machine is used. Therefore, understanding the users requirements becomes important for a company. For welders it is important to be able to operate the welding equipment safely, and to get the expected welding result. The users view welding equipment as a necessary tool to produce goods, and they rely on the producer to account for the quality of the welding machines.

As the developed categories have revealed, generating user benefits in products requires the development engineers to communicate and understand users' needs. Moreover, to identify users' requirements, it is necessary to meet with users, to meet with customers, to avoid users' or customers' hobbyhorses, to learn users' language, to include user perspectives in the development projects, and to design user-friendly machines. Such a close contact with and understanding of users define users as intermediate users, according to Borgers et. al. (2010). Intermediate users represent sticky knowledge, but to get sticky knowledge from these users, places more

responsibility on the development engineers. Furthermore, when the engineers market orientates their development process, products become more market specific. Market orientating the products might increase vulnerability in terms of commercial success, because it tightly links products to specific market behaviour (or specific user behaviour).

An important agent in the user-producer relationship in the studied company is the dealer. The studied company uses dedicated dealers, and their loyalty or disloyalty will affect how the company is able to satisfy user requirements. Kwoka (2001) claims the role of the dealer diminishes because of consumer orders, and purchase systems bring the consumer closer to the production. However, such a view does not consider the innovation capacity in a company. A lacking innovation capacity causes dealers to be disloyal. A company unable to provide users with the same portfolio of products as their competitors looses both dealers' and customers' goodwill, and knowledge. Consequently, a company need to fight for market goodwill by ensuring a competitive portfolio of products.

The empirical data describes how the development tendency within western welding companies towards more automation, fewer well-educated welders, and emigration of welding jobs. A result of these developments is a need for generic welding machines. When welding machines are generic, they are similar to operate independent of the welding process they are meant for. Consequently, welding machines need to be easy to operate, to have a user-friendly exterior, and to be generic. With a similar user interface generic machines enable the users to operate many different machines for different purposes. Further, production of generic machines is more efficient because of reuse of existing machine modules. This market development influences projects and forces the company to consider what development motives they want to pursue, if they want to bring the company forward technically, to update products, and to lift products to market standard. Development motives require the company to engage with suppliers, evaluate competitors products, reduce damage on machines, work to ease certification, evaluate input from sellers, spar with service, consider customer feedback, and consider technological and industrial developments. Consequently, the innovation process promotes contact with external partners, and these relationships relate to what the company can gain from such collaborations and add to their innovation process. In close collaborations, the company might operate as an OEM while loose collaborations can be with users who see the products more as a black box.

9.5 Concluding on Knowledge Harvesting

The category knowledge harvesting needs a broader discussion in relation to organizational learning and to knowledge management. The category knowledge harvesting encompasses how collecting knowledge results from interaction between the participants in product development and their environment (both inside and outside the company) (Tolsby, 2007). Without such interaction, new impulses or inputs cannot be gained, and the product development process closes itself from influences. From this perspective, knowledge harvesting is about how employees make an effort to gain and understand knowledge through interpretations of their work (Ibid.).

According to Mårtensson (2000), the fallacy of knowledge management lies in having a focus on strategy and measurement. Having a measurement focus in knowledge management reduces the importance of understanding and learning processes (Ibid.). What Mårtensson claims is that learning evolves over time, and therefore learning is not necessarily compatible with a focus on measurement. However, a company needs knowledge management and organization skills to develop creative solutions, and they need to learn fast (Hildalgo and Albors, 2008). This dichotomy represents the core of knowledge management. On one hand, learning evolves over time, and on the other hand, to be competitive learning must happen fast. The category knowledge harvesting identifies where knowledge is collected and how knowledge is implemented in order to benefit the development projects. Furthermore, to benefit from the harvested knowledge, the company needs to identify what information the different projects need, and what knowledge to distribute and control. This depends on what products to develop and what knowledge employees' have. The company collects knowledge in relationship with external partners where the company both get access to knowledge and contribute with their own knowledge to the partnership. The knowledge gained through collaboration is fed back into the company's own development projects. Therefore, knowledge harvesting requires investments in external collaborations, and trust in the external partners, and vice versa. The company does not easily break up such collaborations because it is costly, due to the time and resources put into the partnership. Subsequently, the knowledge gained by the company is gradually supplied into the development projects.

Moreover, knowledge management has a mediating role between organizational culture, structure, strategy, and organizational effectiveness (Zheng et. al., 2010). Ekins (2010) claims technology-push and market-pull factors are important aspects of technological change, but the technology-push and market pull factors lack the aspect of social context where changes take place and are therefore insufficient factors by themselves to explain the more widespread changes taking place in innovation processes. Technologies require embedding in a much wider view of the social and

economic system (Ekins, 2010). Freeman and Louça (2001: 121) propose the co-evolution of the five semi-autonomous social subsystems: science, technology, economics, politics, and culture.

Binding a product for a market results from developments within the industrial segments for the products, adoption of a development model, market feedback, and fighting for market goodwill. Furthermore, adoption of a development model, the use of scrutiny, the impact of a slow innovation pace, the product development control, and the dynamic planning of a project, re-focuses the product development. Ekins (2010) does not cover these elements. He focuses on the physical dimension and the socio-economic dimension emphasising production, storage, distribution, entrepreneurs, consumers, and public policy pressure.

A continuous learning takes place in the organization during the commercialization and diffusion phases of product development, which continues throughout product development, design, and market stages (Ekins, 2010; Kemp and Foxon, 2007). In the studied company, solving problems during development leads the development process either in direction of users, dealers, suppliers, research results, technology, materials, or processes. Internally the company uses collaborative work groups to promote sellable products and to support learning during product development. By defining tasks clearly through discussions, employees can better comprehend the tasks, and the collaborating groups are able to produce results (able to produce the correct machines).

What we can infer from this discussion is that companies exist in order to fulfil specific goals and achieve specific results. It should then be reasonable to assume that knowledge management and company strategy will guide their activities.

A central discussion within knowledge management studies is the conversion of tacit into explicit knowledge. However, for the studied company this tacit-explicit dichotomy is subordinate. Management has focus on how to organize their activities and fulfil their strategies in order to use their resources most efficiently. In relation to learning, this implies that companies focus upon how to best manage that knowledge through knowledge harvesting. The ultimate goal for learning within companies is how it will yield a positive impact upon their end–result, either more profit or new possibilities for more profit.

For the company the most important person in a product development project to ensure a successful outcome is the project manager. Without a project manager able to control and guide the development project in the right direction, projects are likely to fail. In this way, the company develops a development policy that gives much power to the project manager. To understand how this power influences decisions one has to acknowledge that power and knowledge are inextricably intertwined (Tolsby and

Kirkebak, 2006). Therefore, power will direct what will be known and who will know (Ibid.).

Furthermore, a company needs to consider that a model for running development projects will always be re-defined by how the employees interpret and understand such a model. The model developed in this thesis results from employees interpretation of their product development reality, and can be used as a guide to understand what factors influence the development process, and how to adjust these factors in order to ensure progression in development projects. Employees' interpretations of their product development problems and decisions are related to concrete problems, involve those facing the problems, and those facing the problems will find solutions to the problems (Tolsby and Kirkebak, 2007).

For the company knowledge harvesting has consequences for the competence, and for the technology, the company wants to build up, and for how the company defines its markets. Knowledge harvesting has consequences for how and why the company enters into external collaborations, for how a company organizes product development teams, for how they manage their development teams, for project managers, for how they organize their productions lines and for how they produce their products.

For development teams, knowledge harvesting is either based on inclusion on demand or closure to build specialist knowledge. In the first instance, knowledge is harvested by including the relevant personnel when their contribution is needed in a project. In the second instance, specialists groups work separately from the development teams in order to mature their core competences in areas such as software or electronics.

For a project manager, knowledge harvesting also involves to educate the project managers for the tasks, and to ensure that the project managers have a personality suitable to manage development teams.

In production knowledge harvesting means to be able to reorganize production teams into rotating groups, and to be able to assemble products using a combination of standard and order production. Furthermore, inclusion of production personnel in the development team as early as possible in the development process helps to make the production more efficient and better organized.

In external collaborations, knowledge harvesting means that the company enters into these collaborations because they want access new ideas, new technology, and process improvement.

Moreover, employees' knowledge is stimulated and harvested to regulate their participation. In practice, this happens through regular meetings, by making an effort to understand employees and customers, by motivating employees' for a project and allow employees to develop knowledge. Failure to communicate correctly with employees will cause violation of the product development process.

Knowledge harvesting influences how the company defines itself in relation to the market. The company emphasises how a new market develops because of the company's ability to interpret the market signals.

A development philosophy emerges because of dealing with the nine categories. This development philosophy ensures a dynamic planning of output, a continuous evaluation of ideas and measuring of the production capacity, processing time, marketing strategies, and products' portfolio.

Current product development methods do not envisage, or support, these central categories in the product development process. Development of future product development methods need to be flexible enough to consider employees comprehensions, otherwise the product development models fail to function as guidance of the development process. Furthermore, the challenges facing the welding industry can be met by applying the nine developed categories.

9.6 Future Research

Future research, could advance and expand the nine categories by applying them to new development processes and models. This could give an opportunity to see how regulating structures impact on behaviour. Bourdieu discusses how regulating structures impact on behaviour: "How can behaviour be regulated without being a product of rules?" (Wilken, 2008: 46), which implies that formality is behaviour.

Furthermore, a product experience extends beyond the pure functionality of a product. It encompasses aesthetics, emotions (on the user behalf), functionality, design, values, and branding. A product should appeal to the user's emotions and create a positive mental responsiveness towards the product. This perspective creates a demand for product design of user-appealing products (Hekkert and Leder, 2008). It would be interesting to know how the participants' understandings of development models are affected by including design issues.

Bibliography

Addleson Mark (2001). Stories about Companies: Boundaries, Structures, Strategies and Processes. *Managerial and Decision Economics,* Jun/Aug, 22(4-5): 169-182.

Allan George (2003). A critique of using grounded theory as a research method, *Electronic Journal of Business Research Methods*, 2 (1): 1-10, http://www.ejbrm.com Accessed 19th November 2007.

Allen, Lise M. (2010). A Critique of Four Grounded Theory Texts. *The Qualitative Report*, 15(6): 1606-1620.

America. (1998). *Vision for Welding Industry*. Miami: Florida.

Andreasen, Myryp Mogens and Hein, Lars (1987). *Integrated Product Development*. Bedford, IFS Publications.

Anderson, J., Reder, L., & Simon, H. (1997). Situated learning and education. Educational Researcher, 25(4): 5-11. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Annells, Merilyn (1996). Grounded Theory Method: Philosophical Perspectives, Paradigm of Inquiry and Postmodernism. *Qualitative Health Research,* 6(3): 379-393.

Antonacopoulou, E. (2006). Working life learning: Learning-in-practise. In: *Learning, working and living: Mapping the terrain of working life learning*, Eds. Antonacopoulou, E., Jarvis, P., Andersen, V., Elkjaer, B., and Hoyrup, S.: 234-254. New York: Palgrave Macmillan.

Argyris, Chris and Schön, Donald A (1996). *Organizational Learning II Theory, Methodand Practice.* Reading, Massachusetts, Addison Wesley-Publishing Company Inc.

Arrow, Kenneth J (1962). The Economic Implications of Learning by Doing. *Review of Economic Studies*, 29: 155-73.

ASM International (2003). *Trends in Welding Research*. Materials Park, Ohio: ASM International.

Aulakh, Preet S., Kotabe, Masaaki and Sahay, Arvind (1996). Trust and Performance in Cross-Border Marketing Partnerships: A Behavioral Approach. *Journal of International Business Studies* 27(5): 1005–1032.

Baker, W.E. and Sinkula, J.M. (1999). The synergistic effect of market orientation and learing orientation on organizational performance. J. acad. Mark. Sci., 27(4):411-427. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Baker, W.E. and Sinkula, J.M. (2002). Market Orientation, learning orientation and product innovation: delving into the organization's black box. J. Market Focus Manage., 5(1): 5-23. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Bahktin, M. (1981). The dialogic imagination. Austin, TX: The University of Texas Press. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4():16-25.

Becker, P. H. (1993). Common pitfalls in published grounded theory research. *Qualitative Health Research*, 3 (?): 254-260.

Becker, M. (2001). Managing Dispersed Knowledge: Organizational Problems, Managerial Strategies and their Effectiveness, Journal of Management Studies, 38(7): 1037-1051. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Berger, P. & Lukmann. T. (1966). *The social construction of reality: A treatise in the sociology of knowledge*. Garden City, NY: Doubleday.

Billett, S. (2006). Relational interdependence between social and individual agency in work and working life. Mind, Culture and Activity, 13(1):53-69. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Bloch, Maurice E F (1998). *How We Think They Think Anthropological Approaches to Cognition, Memoryand Literacy*. Boulder, Westview Press.

Blois, Keith J. (1999). Trust in Business to Business Relationships: An Evaluation of Its Status. *Journal of Management Studies* 36(2):197–215 (March).

Blumer, Herbert (1998). *Symbolic Interactionism Perspective and Method*. Berkeley and Los Angeles, University of California Press.

Bogers, Marcel, Afuah, Allan and Bastian, Bettina (2010). Users as Innovators: A Review, Critique, and Future Research Directions. *Journal of Management*, 35(4): 857-875.

Boreham, N. & Morgan, C. (2004). A socio-cultural analysis of organizational learning. Oxford Review of Education, 30(3):307-325. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Bourdieu, P. (1977). Outline of a theory of practice. Cambridge: Cambridge University Press. In Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Brentani, Ulrike de, Kleinschmidt, Elko J., Salomo, Sören. (2010). Success in Global New Product Development: Impact of Strategy and the Behavioural Environment of the Firm. *Journal of Innovation Management*, 27(2): 143-160.

Bronfenbrenner, U. (1979). The ecology of human development: Experiments by nature and design. Cambridge, MA: Harvard University Press. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Brown, Shona L., Eisenhardt, Kathleen M. (1995). Product Development: Past Research, Present Findings and Future Directions. *Academy of Management Review,* 20(2): 343-378.

Brunsson, Nils (2000). *The Irrational Organization Irrationality as a Basis for Organizational Action and Change*. Copenhagen, Copenhagen Business School Press.

Bstieler, Ludwig (2006). Trust formation in Collaborative New Product Development. *The Journal of Product Innovation Management*, 2006, 23: 56-72.

Bunge, Mario (1993). Realism and Antirealism in Social Science. *Theory and Decision*, 35(3): 207-235.

Cambridge, (2007a). *Cambridge Online Dictionary*. http://dictionary.cambridge.org/define.asp?key=HW*1060&dict=CLD2. Accessed 19th November 2007.

Cambridge, (2007b). *Cambridge Online Dictionary*. http://dictionary.cambridge.org/define.asp?key=44130&dict=CALD. Accessed 19th November 2007.

Carlsson, (2003). The New Economy: What is New and What is Not?. In: Christensen-Frøslev, Jens and Maskell, Peter. (2003). *The Industrial Dynamics of the New Digital Economy*. Cheltenham: Edward Elgar Publishing, Inc.

Cary, Howard. (1998). *Modern Welding Technology*. New Jersey: Prentice Hall.

Cary, Howard B., & Scott, C. Helzer. (2005). *Modern Welding Technology*. New Jersey: Pearson Eduction.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* London:Sage.

Chesbrough, Henry (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. In: Cooper, Robert and Edgett, Scott, Ideation for Product Innovation: What are the best methods? *PMA Vision Magazine*, Reference Paper #29, March 2009.

Christensen Frøslev, J. (2003). Innovation, Entreprenaurship and Industrial Dynamics in Internet Services. In: Christensen Frøslev, J, and Maskell, P. (2003). *The Industrial Dynamics of the New Digital Economy*. Edward Elgar Publishing Limited: Cornwall

Clarke, A. (2005*). Situational Analysis: Grounded Theory After the Postmodern Turn.* Thousand Oaks, CA: Sage Publications.

Cohen, W. M. and Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. In: Bogers, Marcel, Afuah, Allan and Bastian, Bettina (2010). Users as Innovators: A Review, Critique, and Future Research Directions. *Journal of Management*, 35(4): 857-875.

Coleman James S., (1988). Social Capital in the creation of Human Capital. *American Journal of Sociology,* 94 Issue Supplement: Organizations and Institutions: Sociological and Economic Approaches to the Analysis of Social Structure: 95-120.

Cooper, Robert G. (1991). Stage-Gate Systems: A New Tool for Managing New Products. *IEEE Engineering Management Review*, 19(3): 5-12.

Cooper Robert G. (1994). Perspective: Third Generation new product process. *Journal of Product Innovation Management* 11(3): 13-14.

Cooper Robert G., Kleinschmidt Elko J. (1997). Portifolio Management in New Product Development: Lessons from the Leaders-II. *Research Technology Management* 40(5): 43-52.

Cooper Robert G., Kleinschmidt Elko J (2000). New Product Performance: What Distinguishes the Star Products. *Australian Journal of Management,* 25(1): 17-45.

Cooper Robert G. (2001). *Stage-Gate model: Winning at New Products*. MA, Cambridge: Basic Books.

Cooper, R.G. and S.J. Edgett. (2008). Ideation for Product Innovation: What are the best methods?. *PDMA Visions Magazine*, Reference Paper # 29. Stage-Gate International and Product Development Institute Inc., March 2008.

Denker Stephen, Steward, Donald V., Browining, Tyson R. (2001). Planning Concurrency and Managing Iteration in Projects. *Project Management Journal,* 23(3): 31-38.

Corbin, J. and Strauss, A. (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. London: Sage.

Creswell, John W. (1998). *Qualitative Inquiry and Research Design Choosing Among Five Traditions*. Thousand Oaks, California: Sage.

Darroch, J. and McNaugton, R. (2003). Beyond market orientation: knowledge management and the innovativeness of New Zeeland firms. Eur. J. Mark., 37(3/4): 572-593. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(4): 408-417.

Day, G.S. (1994). The capabilities of the market-driven organizations. J. Mark., 58(4):37-52. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(4): 408-417.

Dewey, John (1908). What Does Pragmatism Mean by Practical? *The Journal of Philosophy, Psychology and Scientific Methods*, 5(4): 85-99.

Dirks, Kurt T. (1999). The Effects of Interpersonal Trust on Work Group Performance. *Journal of Applied Psychology* 84(3):445–455.

Dogson, M. (2000). The Management of Technological Innovation. In:
Hildalgo, Antonio and Albors, Jose (2008). Innovation management techniques and tools: a review from theory to practice. *R&D Management*, 38(2): 113-127.

Easterby-Smith, M., Snell, R.& Gherardi. S. (1998). Organizational learning and learning organizations: Divering communities of practice? Journal of Management Inquiry, 2(4): 259-272. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Easterby-Smith, Mark, Burgoyne, John and Araujo, Luis (1999). *Organizational Learning and the Learning Organization Developments in theory and practice*. Gateshead, SAGE Publications Ltd.

Ekins, Paul (2010). *Hydrogen Energy Economic and Social Challenges*. Bristol: Earthscan, :9-28.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Helsinki: Orienta-Konsultit. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program

renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. Journl of Education and Work, 14(1):133-156. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Enkel, Ellen, Gassman, Oliver and Chesbrough, Henry. (2009). Open R&D and open innovation: exploring the phenomenon. *R&D Management*, 30(4).

Filo, C. M. and Lyles, M. A. (1985). Organizational Learning. Acad. Manage. Rev., 10(4): 803-813. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research,* 64(4): 408-417.

Flyvebjerg Bernt (1999). *Making Social Science Matter: Why Social Inquiry Fails and How It Can Succeed Again*, Cambridge, Cambridge University Press.

Freeman, C. and Louça, F. (2001). As time gores by. Oxford University Press, Oxford. In: Ekins, Paul (2010). *Hydrogen Energy Economic and Social Challenges.* Bristol: Earthscan, :9-28.

Garcia, R and R Calantone. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management,* 19(2): 110-132.

Gavin, David A. (1993). Building alearning organization. Harv. Bus. Rev., 71(4): 78-91. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(4): 408-417.

Geels, F.W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy* 31, 1257-1274.

Gherardi, S. (2000). Practice Based Theorizing on Learning and Knowing in Organizations, Organization, 7(2): 211-233. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Gherardi, S. & Nicolini, D. (2001). The sociological foundations of organizational learning. In Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1): 16-25.

Giddens, A. (1984). The constitution of society: Outline of the theory of structuration. Berkeley, CA: Jossey-Bass. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation, and change. *Educational Research Review*, 4(1):16-25.

Glaser, B. G. (1994). *Basics of grounded theory analysis: Emergence versus forcing*. Mill Valley, CA: Sociology Press.

Glaser, Barney G and Strauss, Anselm L (1999). *The Discovery of Grounded Theory Strategies for Qualitative Research*. Chicago, Aldine Publishing Company.

Greeno, J. (1998). The situativity of knowing, learning and research. American Psychologist, 53(1): 5-26. In Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation, and change. *Educational Research Review*, 4(1):16-25.

Goulding, C., (2002). *Grounded theory: A practical guide for management, business, and market researchers*. Thousands Oaks CA.: Sage Publications.

Hammersley Martyn and Atkinson Paul (1987). *Feltmetodikk Grunnlaget for feltarbeid og feltforskning* (Ethnography: Principles in Practice). Oslo, Notam Gyldendal.

Han, J. K., Kim, N., Shrivastava, R. (1998). Market orientation and organizational performance, 62(4): 30-45. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(4): 408-417.

Hawking, Stephen (1988). *A Brief History of Time from the Big Bang to the Black Holes*. Chapter 3, Bantam Books.

Hardin, Russell (1996). Trustworthiness. *Ethics*, 107 (1) October, : 26-42.

Hart, Chris (1998). *Doing a Literature Review Releasing the Social Science Research Imagination.* London, Sage Publications.

Hart, Susan J. and Baker Michael J. (1994). The Multiple Convergent Processing Model of New Product Development. *International Marketing Review*, 11(1): 77-92.

Hedberg, B. (1981). How Organizations Learn and Unlearn. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Hekkert, Paul and Leder, Helmut (2008). Product aesthetics. In: by Hendrik N. J. Schifferstein and Paul Hekkert, *Product Experience,* 2008: 259-285. Oxford: Elsevier Ltd.

Hildalgo, Antonio and Albors, Jose (2008). Innovation management techniques and tools: a review from theory to practice. *R&D Management*, 38(2): 113-127.

Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Holloway, Wendy and Jefferson, Tony (2000). *Doing Qualitative Research Differently Free Association, narrative and the interview method*. Wiltshire, Sage Publications Ltd.

Holweg, Matthias, Luo, Jianxi and Oliver, Nick (2009). The past, present and future of China's automotive industry: a value chain perspective. *International Journal of Technological Learning, Innovation and Development*, 2 (1-2) 2009, 76-118.

Honig, M.I. (2008). District central office administration s learning: How socio-cultural and organizational learning theories elaborate district-central-office participation in teaching and learning improvements efforts. American Journal of Education, 114(4):627-644. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Huber, George P. (1991) Organizational learning the contributing processes and the literatures. Organ. Sci., 2(1):88-115. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research,* 64(*4*): 408-417.

Hudson, Ray (1999). The Learning Economy, The Learning Company and The Learning Region: A Sympathetic Critique of The Limits to Learning. *European Urban and Regional Studies,* 6(*1*): 59-72.

Huges, John and Sharrock, Wes (1997). *The Philosophy of Social Research.* Essex, Longman.

Hurley, R. E. and Hult, G.T.M. (1998). Innovation, market orientation and organizational learning: an integration and empirical examination. J. Mark., 62(3):42-54. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Isaacs, W. (1993). Taking flight: Dialogue, collective thinking, and organizational learning. *Organizational Dynamics,* 22(*2*): 24-39.

Illeris, Knud (1999). *Læring - aktuell læringsteori i spenningsfeltet mellom Piaget, Freud og Marx.* (My translation: Learning – Current Learning Theory between Piaget, Freud and Marx). Gylling, Roskilde Universitetsforlag.

Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Johnson, B. and Lundvall, B. Å. (1994). The learning economy. *Journal of Industry Studies*, 1(*2*): 23-42.

Johnson, Bjørn, Lorenz, Edward and Lundvall Bengt-Åke. (2002). Why all this fuss about codified and tacit knowledge. *Industrial and Corporate Change*, 11(*2*): 245-262.

Jones, Karen. (1996). *Trust as Affective Attitude*, *Ethics,* 107 (*1*): 4-25.

Josefson, Ingela. (1991). *Kunskapens former Det reflekterande yrkeskunnande*. (My translation: Knowledge forms Reflective Vocational Knowledge). Stockholm: Carlssons Bokförlag.

Kant, Immanuel (1781/1958). *Critique of Pure Reason*. Translated by Norman Kemp Smith. London: Macmillan.

Kemp, R. and Foxon, T. (2007). Eco-innovation from and innovation dynamics perspective. In: Ekins, Paul (2010). *Hydrogen Energy Economic and Social Challenges.* Bristol: Earthscan: 9-28.

Kline, S.J. and Rosenberg, N. (1986). An Overview of Innovation. In: Ekins, Paul (2010). *Hydrogen Energy Economic and Social Challenges.* Bristol: Earthscan: 9-28.

Kogut,B. and Zander. U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. Organi. Sci., 3(3):383-397. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science*, 47(*1*): 1-21.

Kwoka, (2001). Automobiles: The Old Economy Collides with the New. *Review of Industrial Organisation.* 19(*1*): 55-69.

Lave, J. (1988). *Cognition in Practice: Mind, mathematics, and culture in everyday life.* Cambridge, UK: Cambridge University Press.

Lave, Jean and Wenger, Etienne (1991). *Situated Learning: legitimate peripheral participation*. Cambridge, Cambridge University Press.

Lehesvirta, T. (2004). Learning processes in a work organization: From individual to collective and/or vice versa? Journal of Workplace Learning, 16(1/2): 92-100. In Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(*1*):16-25.

Levitt, B. and March, James G. (1988). Organizational learning. Annual Review of Sociology, 94, : 319-340. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Lewis, J. David and Weigert, Andrew (1985). Trust as Social Reality. *Social Forces* 63(4):967–985.

Locke, Karen (2001). *Grounded Theory in Management Science.* Biddles Ltd, Surrey. Loch and Terwiesch, 1998).

Lund, Reinhard. (2001). *Product innovation from a competence development perspective*. Working paper, LOK Project 3.3. Presented at LOK Research Conference, 3-4 December 2001, Hundsgaul.

Lundvall, Bengt-Åke (1985). Product Innovation and User-Producer Interaction. *Industrial Development Research Series*, No. 31, Aalborg University Press, 1985.

Lundvall, Bengt-Åke (1988). Innovation as an interactive process: from user-producer interaction to national system of innovation. In: Dosi G. et.al (eds), *Technical change and Economic Theory* by London, Pinter.

Lundvall, Bengt-Åke (1992). *National Systems of Innovation Towards a Theory of Innovation and Interactive Learning.* London, Pinter.

Lundvall, Bengt-Åke (1996). The social dimension of the learning economy. *DRUID Working Papers,* No 1, 1996.

Lerdahl, Erik (2007). *Slagkraft. Håndbok i ideutvikling*. Oslo: Gyldendal Norsk Forlag.

Lincoln Electric (1994). *The Procedure Handbook of Arc Welding. Cleveland: Lincoln Electric.*

López, S.P., Peón, J.M.M., & Ordás, C.J.V. (2004). Managing Knowledge: The Link Between Culture and Organizational Learning, Journal of Knowledge Management, 8(6): 93-104. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

March, James G. & Simon, Herbert A. (1958). *Organizations:* New York: Wiley.

Mannion, Bernhard, and Mannin, Liam (1999). Trends in the Welding Industry. *Flow Control Magazine*, March (1999).

Martin, Patricia Yancey and Turner, Barry A (1986). Grounded Theory and Organizational Research. *The Journal of Applied Behavioural Science* 22(2): 141-157.

May, Carl (2009). From Grounded Theory to the Practice of Theory Building. *Opinion Piece / Medical Sociology* online 4(2), (Dec 2009): 46-49.

McGrath, Michael E. (1996). *Setting the PACE in Product Development: A Guide to Product and Cycle-time Excellence*. USA: Butterworth-Heinemann.

Mead, George Herbert. (1912). The Mechanism of Social Consciousness. *The Journal of Philosophy, Psychology, and Scientific Methods*. 9(15): 401-406 (Jul 18 1912).

Mead, George Herbert (1967). *Mind, Self, & Society from the Standpoint of a Social Behaviorist.* Chicago: University of Chicago Press Ltd.

Mikkelsen Hans, Andreasen Myryp M, Hein Lars. (1989).*Risikohåndtering i produktudvikling (My translation: Dealing with Risks during Product Development)*. Lyngby: Instituttet for Produktudvikling DTH, 1989: 1-67.

Miles, R.E. and Snow, C.H.C. (1978). Orgnaizational strategy, structure and process. New York: McGraw Hill. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Mårtensson, Maria (2000). A critical review of knowledge management as a management tool, *Journal of Knowledge Management*, 4(*3*): 204-216.

Nevins, J.L. and Whitney, D.E. (1989). Concurrent Design of Products and Processes: A strategy for the Next Generation in Manufacturing, McGraw-Hill Company, NY. In: Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science,* 47(1): 1-21.

Nonaka Ikujiro and Noboru Konno (1998). The concept of BA: Building a Foundation for Knowledge Creation. *California Management Review* 40(3): 40-54 (Spring 1998).

Orlikowski, W. (2002). Knowing in Practice: Enacting a Collective Capability in Distributed Organizing, Organization Science, 13(*3*): 249-273. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Oxford Dictionary Online (2007) (http://www.askoxford.com/results/?view=dev_dict&field-12668446=dilettante&branch=13842570&textsearchtype=exact&sortorder=score%2Cname). Accessed 08th March 2007.

Phaal, R., Farrukh, C.J.P and Probert, D.R. (2006). Technology management tools: concept, development and application. Technovation, 26, :336-344. In: Hildalgo, Antonio and Albors, Jose (2008). Innovation management techniques and tools: a review from theory to practice. *R&D Management,* 38(2): 113-127.

Pavitt, Keith (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy* 13 (1984) 343-373. Elsevier Science Publishers B.V (North-Holland).

Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(*1*):16-25.

Polanyi, Michael (1983). *The Tacit Dimension*. Gloucester Madd: Peter Smith, 1983, :1-107.

Pugh, Stuart (1991). *Total Design Integrated Methods for Successful Product Engineering*. Essex, Addison-Wesley Pub.

Pålshaugen Ø. (1992). Aksjonsforskning: En nyttig vitenskap? Et innspill i fire satser. (Action Research: A useful science? An initiative in four movements). *Tidsskrift for samfunnsforskning* 1992, Årgang 33, p.231-251.

Rasmussen Gulddahl Jørgen, Poul Nørgaard Dahl, Kenneth Mølbjerg Jørgensen, Erik Laursen og Palle Rasmussen (2001). *Perspektiver på organisatorisk læring* (My translation: Perspectives on Organizational Learning). Center for Organisatorisk Læring Juni 2001, VCL-serien nr. 28, ISSN 1399-7300, Videncenter for Læreprocesser Aalborg Universitet.

Raz, A. & Fadlon, J .(2006). Managerial Culture, Workplace Culture and Situated Curricula in Organizational Learning, Organization Studies, 27(*2*): 165-182. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Riessman, Kohler Cathrine (1993). *Narrative Analysis*. California, Sage Publications.

Robinson, V. (2001). Descriptive and normative research on organizational learning: Locating the contribution of Argyris and Schon. International Journal Educational Management. 15(2): 58-67. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1): 16-25.

Rogoff, B., Baker-Sennet, J., Lacasa, P. & Goldsmith, D. (1995). Development through participation in socio-cultural activity. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1): 16-25.

Rosenberg, N. (1982). *Inside the Black Box: Technology and Economics*. Cambridge University Press, Cambridge.

Sewell, W. (1992). A theory of structure: Duality, agency and transformation. The American Journal of Sociology, 98(1):1-29. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Schirato Tony and Yell Susan (2000). *Communication and Cultural Literacy*. Sydney and London, Allen & Unwin/Sage.

Schön, Donald A. (1983). *The Reflective Practitioner How Professionals Think in Action*. USA, Basic Books Inc.

Schultze, U. & Stabell, C. (2004). Knowing What You Don't Know: Discourse and Contradictions in Knowledge Management Research. Journal of Management Studies, 41(4): 549-573. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Schweissen & Schneiden, 2009. The Essen Welding Show, December 31 2009. http://www.essentradeshows.com/exhibitor/welding.html. Accessed 31st December 2009.

Sellars, Roy Wood (1924). Critical Realism and Its Critics. *The Philosophical Review,* 33(4): 379-397.

Senge, Peter M (1990). *The Fifth Discipline The Art & Practice of The Learning* Organization. London, Century Business.

Shipton, H. (2006). Confusion or Cohesion? Towards a Typology for Organizational Learning Research, International Journal of Management Reviews, 8(4): 233-252. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Shrivastava, P. (1983). A Typology of Organizational Learning Systems, Journal of Management Studies, 20(1): 7-28. In: Hislop, Donald. (2009*). Knowledge Management in Organizations*. New York: Oxford University Press.

Sinkula, J.M. (1994). Market information processing and organizational learning. J. Mark., 58(1): 35-45-. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). In: novation, organizational learning, and performance. *Journal of Business Research,* 64(*4*): 408-417.

Slater, S.F. and Naver, J.C. (1995). Market orientation and the learning organization. J. Mark., 59(3): 63-74. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. Journal of Business Research, 64(*4*): 408-417.

Strauss, A. & Corbin, J. (1997). *Grounded Theory in Practice*. Thousand Oaks: Sage Publications Ltd.

Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: Techniques and Procedures for Developing Grounded theory*. Newbury Park: Sage.

Strauss, A. (2003). *Qualitative analysis for social scientists*. New York: Cambridge University Press.

Tippins, M.J. and Sohi, R.S. (2003). It competency and firm performance: is organizational learning a missing link. Strateg. Manae., J., 24(8): 745-761. In: Jiménez-

Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(4): 408-417.

Thomessen, Amie. (2009). *Stanford Encyclopedia of Philosphy*. Metaphysics Research Lab CSLI, Stanford University, accessed, http://plato.stanford.edu/entries/categories/. Accessed 19th of November 2011.

Tolsby, June, and Kirkebak, Per. (2006*). The Power of Politics on Organizational Learning and Knowledge Creation.* Paper presented at OLKC International Conference onf Organizational Learning, Knowledge and Capabilities 20-22nd March 2006, University of Warwick, Warwick Business School, UK.

Tolsby, June. (2007). *Making Employees Interpretation of Product Development Work Comprehensible using a Grounded Theory Approach*. ECRM Proceedings 2007 – The 6th European Conference on Research Methodology for Business and Management Studies, Unviersidade Nova de Lisboa, Lisbon, Portugal 9-10th July, 2007.

Tolsby, June and Kirkebak, Per. (2007). Partaking as a Tool for Knowledge Creation and Sharing in Practice. *The Electronic Journal of Knowledge Management*, 5(1): 115-122. www.ejkm.com

Ulrich, K.T. (1995). The Role of Product Architecture in the Manufacturing Firm. Research Policy, 24(May): 419-440. In: Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science*, 47(1): 1-21.

Ulrich, Karl T. and Ellison, D.E. (1998). Beyond make-buy: internalization and integration of design and production. Working paper, Department of Operations and Information Management. The Wharton School, Philadelphia, PA. In: Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science*, 47(1): 1-21.

Ulrich, K. and Eppinger, S. D. (2000). Product Design and Development, Second Edition, McGraw-Hill: New York. In: Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science*, 47(1): 1-21.

Unger, Darian W. and Eppinger, Steven D. (2009). Comparing product development processes and managing risk. *Int. J. Product Development*, 8(4).

Urban, G. and Hauser, J. (1993). Design and Marketing of New Products. Prentice Hall, Englewood Cliffs, NJ. In: Krishnan, V. and Ulrich, Karl T.(2001). Product Development Decisions: A Review of Literature. *Management Science,* 47(1): 1-21.

Vince, R. (2001). Power and emotion in organizational learning. Human Relations, 54(10):1325-1351. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Vygotsky. L.S. (1978). Mind and society: The development of higher mental processes. Cambridge, MA: Harvard University Press. In: Peck, Charles A., Chrysan Gallucci, Tine Sloan, Ann Lippincott (2009). Organizational learning and program renewal in teacher education: A socio-cultural theory of learning, innovation and change. *Educational Research Review*, 4(1):16-25.

Webb Jen, Schirato Tony, Danaher Geoff (2002). *Understanding Bourdieu*. Crows Nest and London, Allen & Unwin/Sage Publications Ltd.

Wenger, Etienne (1998). *Communities of Practice Learning, Meaning and Identity. Cambridge*, Cambridge University Press.

Wilson, David T. and Möller, Kristian (1995). Dynamics of Relationship Development. In: Kristian Möller and David T. Wilson (eds.). *Business Marketing: An Interaction and Network Perspective.* Norwich, MA: Kluwer Academic Publishers, 53–69.

Weman, Klas (2003). *Welding processes handbook*. New York: CRC Press LLC.

Wilken, Lisanne (2008). *Pierre Bourdieu*. Trondheim: Tapir akademisk forlag.

Yli-Renko, H., Autio, E., Sapienza, H.J. (2001). Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. Strate., Manage J., 22(6-7): 587-613. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. Journal of Business Research, 64(*4*): 408-417.

Yin, Robert K (1994). *Case Study Research Design and Methods*. Thousand Oaks, Sage Publisher Ltd.

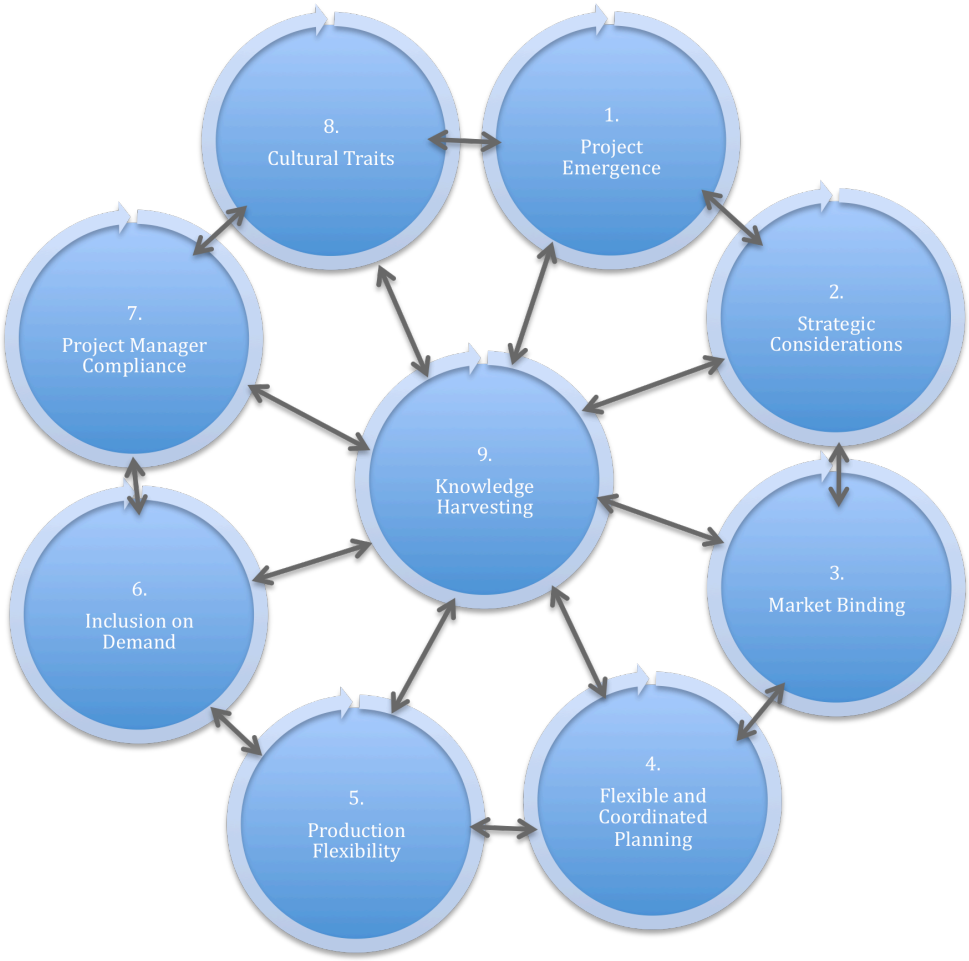
Zheng, Wei, Yang, Baiyin, McLean, Gary N. (2010). Linking organizational culture, structure, strategy, and organizational effectiveness: mediating role of knowledge management. J. Business Research, 63(7): 763-771. In: Jiménez-Jiménez, Daniel and Sanz-Valle, Raquel. (2011). Innovation, organizational learning, and performance. *Journal of Business Research*, 64(*4*): 408-417.

Appendix I: Table of Companies

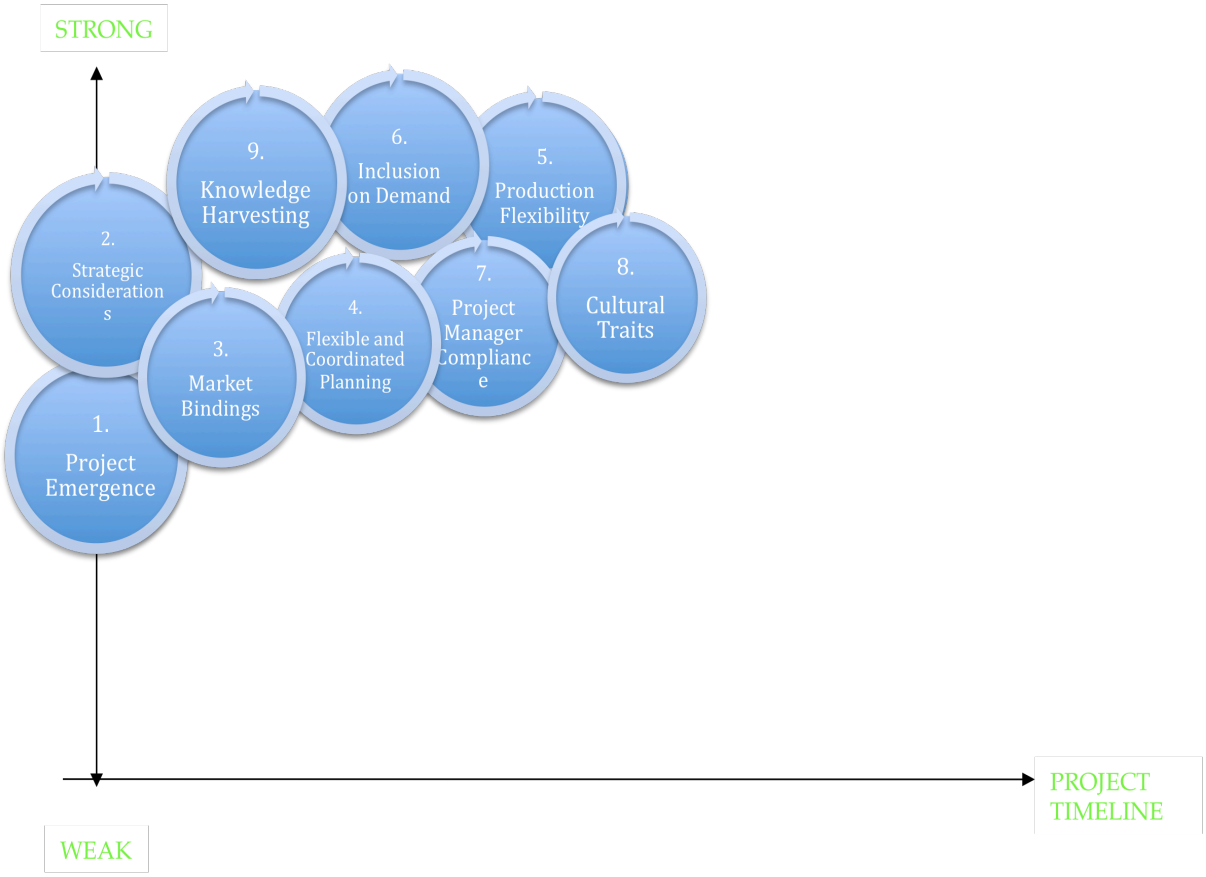
The empirical data used in this thesis is taken from company B.

Company	Industry	Project(s) followed	Interviews made	Interview rounds	Companies that ceased to participate in the study
A	Service company	No particular	1	1	Pilot interview.
B	**Machine company**	**Weld machines – 2 projects**	**9**	**4**	
C	Metal preparation company	Commutator	3	2	After 2 rounds of interviews the company ran into money problems.
D	Electronic company	In-house light controlling equipment – 2 projects	10	4	
E	Machine company	Cattle – 2 projects	11	4	
F	Machine company	Fodder machine - 2 projects	7	3	After 3 rounds, lack of interest from the company in combination with organizational changes.
G	Furniture company	Office furniture	2	2	Long-term illness, not possible to continue.
H	Electronic company	Printer	10	4	
I	Service company	Internet software	5	3	Ran into money problems.
J	Food Producing Company	Spices	1	1	Withdrew due to reorganizations of the company.
K	Service company	ICT Network solutions	1	1	After several attempts for further interviews the company show no real interest in participating

Appendix II: Developed Categories



Appendix III: Developed Model



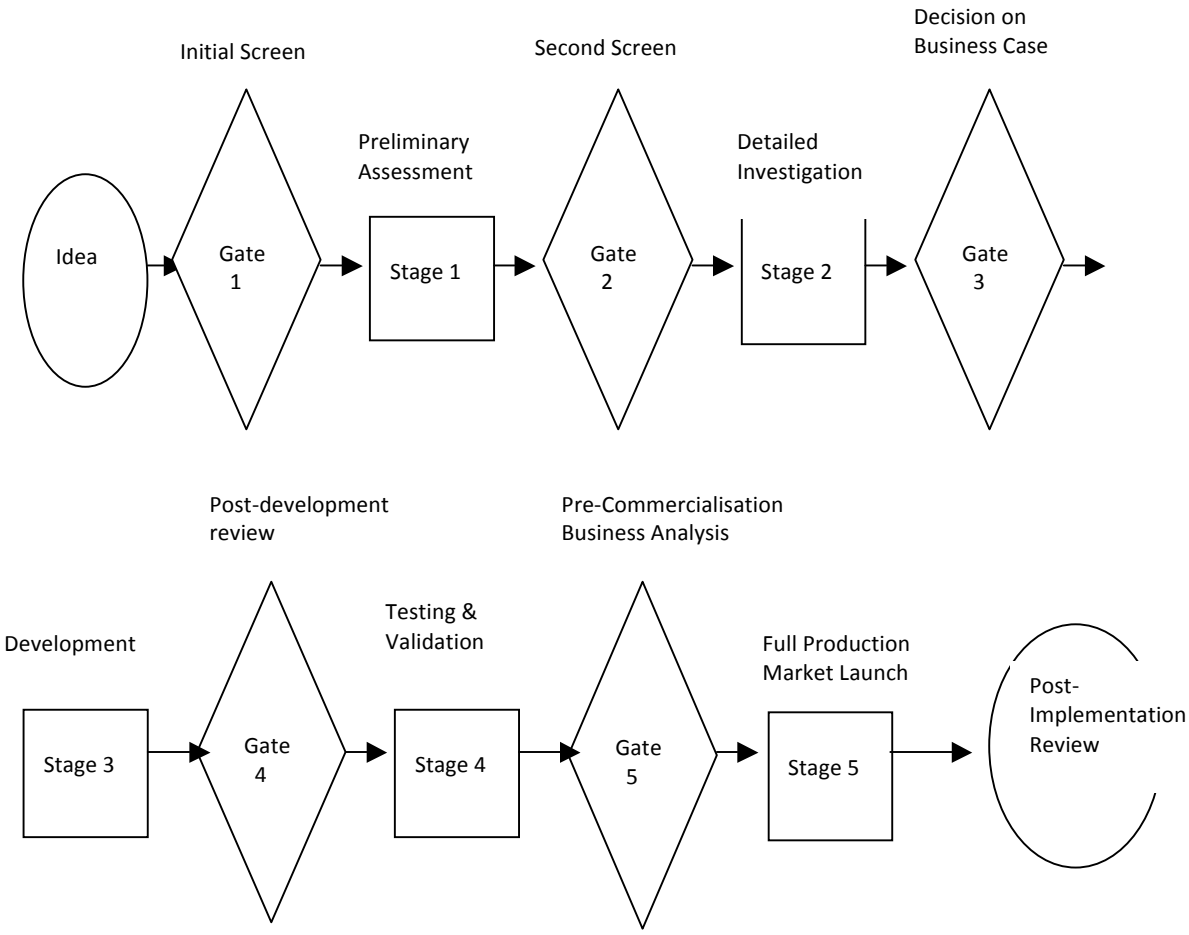
Appendix IV: Integrated Product Development model

Needs-Situation	Determining the principal needs	User-investigation	Market-determination	Preparing Sales	Sales
	Determining-product type	Principle-construction	Product-shaping	Product-maturation	Product-adjustments
	Process type-consideration	Production-type-determination	Production-principles-determined	Product-preparation	Production
0. Needs-recognition-phase	1. Needs-investigation-phase	2. Product-principles-Phase	3. Product-shaping-Phase	4. Production-preparation-phase	5.Realisation-Phase

Integrated Product Development phases adapted from Andreasen and Hein (Andreasen and Hein, 1987: p.35).

Appendix V: Stage-Gate Model

Overview of a Stage-Gate System adapted from Cooper (1991: 7).



Appendix VI: Memo sent to Company

Fra Forskningsgruppen Peter Byebierggaard, Reinhard Lund, June Tolsby

Tilbagemelding 2
PIE-Projekt: Produktinnovation, interaktiv læring og økonomiske resultater

Indledning

I perioden juni - november 2000 blev besøg nr.2 gennemført i 7 virksomheder, mens 3 genbesøg er planlagt til december-januar. I centrum for det 2. besøg har stået mere detaljerede oplysninger om konkrete produktudviklingsforløb. Det har bl.a. betydet, at flere virksomheder har givet muligheder for samtaler med flere medarbejdere inden for udvikling, produktionsteknik, produktion og montage, indkøb og salg. Disse samtaler har fokuseret på en række områder, der skal nævnes nedenfor, samtidig med at der opregnes nogle emner, som det generelt kunne være frugtbart at drøfte ved et 3. besøg. Mere specifikke spørgsmål til de deltagende virksomheder og udpegning af medarbejdere, som det vil være naturligt at inddrage, aftales naturligvis med den enkelte virksomhed.

Emner for den fortsatte undersøgelse af produktinnovation, læring og resultater

1. KUNDEØNSKER. Virksomhederne har signaleret, at kundeønsker er centrale for produktudviklingen. Hvordan udkrystalliseres disse ønsker? Hvilken kommunikation foregår internt i virksomheden? Hvor stærkt styrer virksomhedens overordnede strategi accept eller afvisning af ønskerne?. Hvormeget frirum har udviklingsafdeling og den enkelte produktudvikler (og eventuel gruppe)?

2. KOBLINGER MELLEM VIRKSOMHED OG LEVERANDØRER. Der er givet flere eksempler på en bevidst fordeling af ansvar. I hvilken grad tilstræbes et fælles udviklingsarbejde. Hvilke hindringer er der herfor?

3. PLANLÆGNING AF PRODUKTUDVIKLING. De besøgte virksomheder tilstræber alle at koordinere produktudviklingsaktiviteterne på tværs af virksomhedens funktioner. Her er eksempler på arbejde i teams med tværgående deltagelse og produktudviklere som tilrettelægger tværgående kontakter. Valget kan afhænge af produktarbejdets omfang, men hvilke andre forhold indgår i overvejelserne om de tværgående kontakters tilrettelæggelse igennem produktudviklingsforløbet? Hvilke erfaringer har medarbejdere fra forskellige funktioner gjort igennem deres større eller mindre inddragelse i tværgående kontakter?

4. ØKONOMISKE RESULTATER. Der er ikke ved de første to besøg indsamlet mange oplysninger om økonomiske resultater. Hvad foreligger der af oplysninger om resultater af produktudvikling inden for de seneste år. Hvordan anvendes disse resultater?

5. KOMPETENCEOPBYGNING. Ved de to besøg er konstateret, at medarbejderne oparbejder ny viden gennem gruppedrøftelser, eksperimenter, litteraturstudier og kursus. På hvilke områder prioriterer virksomhederne medarbejdernes fortsatte kompetenceopbygning af betydning for produktudviklingens succes. Hvad gøres der inden for de forskellige afdelinger, som tilsammen betyder noget for produktudviklingen.

Appendix VII: List of Figures

Appendix VIII: List of Tables

Appendix IX: Complete Data Analysis

(The complete data analysis is provided in a separate booklet.)